Santa Barbara

GENERAL PLAN

Proposed Safety Element

April 2013

City of Santa Barbara

Public Review Draft

Proposed General Plan Safety Element

City of Santa Barbara
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April 2013

Funded in part by the Housing and Urban Development, Community Development Block Grant Disaster Recovery Initiative

CITY OF SANTA BARBARA
PROPOSED SAFETY ELEMENT (2013)
PUBLIC REVIEW DRAFT

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Safety Element Introduction

The City's original Seismic Safety/Safety Element was adopted in 1979 and addressed physical hazards related to geology, earthquakes, fire and flooding. The 2013 update to the 1979 Seismic Safety/Safety Element is now referred to as the "Safety Element" and provides information about a variety of natural and human-caused hazards, and also provides improved maps depicting areas of the City that may be affected by hazards.

The 2013 Safety Element addresses several issues not included in the 1979 Seismic Safety/Safety Element, including hazards associated with the effects of climate change; hazardous material use; and public safety risks resulting from aircraft operations, the use of local highways and rail lines for the transport of hazardous materials, natural gas pipelines, electrical transmission lines, and electromagnetic fields. The 2013 Safety Element also provides information about public services provided by the City related to hazard and risk reduction programs, and describes emergency response planning programs that foster community resilience should a disaster occur. With a focus on risk reduction through enhanced information and policy guidance, the 2013 Safety Element also supports the land use permitting and environmental review processes.

WHY PREPARE A SAFETY ELEMENT?

The Safety Element is a required component of the City's General Plan and specific items to be addressed by the Safety Element are prescribed by California Government Code Section 65302(g). This Section states, in part, that a Safety Element is to be prepared "*for the protection of the community from any unreasonable risks associated with the effects of seismically induced surface rupture, ground shaking, ground failure, tsunami, seiche, and dam failure; slope instability leading to mudslides and landslides; subsidence, liquefaction, and other seismic hazards…*"

Additional guidance regarding the preparation of the Safety Element is provided by the *General Plan Guidelines* (2003), prepared by the Governor's Office of Planning and Research. The *General Plan Guidelines* indicate that "*the aim of the safety element is to reduce the potential risk of death, injuries, property damage, and economic and social dislocation resulting from fires, floods, earthquakes, landslides, and other hazards.*" The *Guidelines* also indicate that the Safety Element may address other relevant safety issues that are considered important.

Human-caused hazards can also result in serious effects to health and property, and are often created as a result of modern activities and technologies that our society has become dependent upon. In the Santa Barbara area, human-caused hazards can result from energy use and transmission, the use and transport of hazardous substances, and airport-related hazards.

Natural and human-caused hazards do not affect Santa Barbara uniformly as some areas of the City are more susceptible to the effects of certain hazards than other areas of the community. Hazard maps provided in the Safety Element depict the general locations and possible severity of various hazards and are important tools in identifying and reducing the potential effects of hazards and for hazard response planning.

HAZARDS, RISKS AND VULNERABILITY

The terms "hazard" and "risk" are interrelated but convey distinctly different concepts. A hazard can be a physical process, substance, or event that has the potential to produce harm to health or property. Should a hazard affect a property or community, the consequences of the event can be expressed in a variety of ways, but it is common to describe hazard-related outcomes as ranging between negligible and catastrophic. Another term that is commonly used in evaluating how hazards may affect a community is "vulnerability," which is used to express the degree of exposure to a particular hazard.

A risk is the likelihood of adverse effects resulting from exposure to a hazard. Risk is determined by assessing its two components: the possible consequences of being exposed to a hazard and the probability that the hazard may occur. The probability of a hazard occurring can be described as ranging between improbable and certain, or as having a low, moderate, or high potential to occur.

In land use planning, it is generally accepted that the effects of most natural and human-caused hazards can be reduced but not eliminated. Risk reduction can be achieved in many ways, but often involves requirements to avoid or minimize the use of areas commonly affected by a hazard, building structures that are resistant to the effects of specific hazards, and/or by implementing practices and procedures that minimize the potential for the hazard to occur or to reduce its effects should it occur. Since the risk of being exposed to hazards generally cannot be eliminated, an objective of the land use planning process is to minimize risk to the point that it becomes "acceptable."

Making a determination as to when a particular risk is considered acceptable includes factors other than risk probability and consequence. For example, a higher level of risk may be considered acceptable in instances when the risk exposure is voluntary rather than involuntary, or if overriding community benefits may be achieved by accepting a certain level of risk. Other considerations in the risk assessment process may include the technical feasibility and economic cost of achieving each additional increment of risk reduction, and how well the probability of risk occurrence and potential hazard outcomes are understood.

After considering these and other variables, the community and decision-makers determine what level of safety is considered sufficient, or in other terms, how safe is safe enough.

COMMUNITY RESILIENCE

An objective of implementing hazard-related risk reduction measures and planning for effective post-disaster response is to facilitate the rapid recovery of the community after a disaster occurs. The combined benefits of minimizing risk and pre-disaster planning are often referred to as "resiliency planning" and can reduce the effects of natural and other hazards in terms of injury and loss of life, property damage, and loss of natural and economic resources. Communities that actively engage in hazard and resiliency planning will likely be less seriously affected by a disaster, will recover faster when disasters occur, and endure less economic hardship than those communities that do not engage in planning-related efforts. Resiliency planning promotes recovery from the short- and long-term effects of natural disasters such as earthquakes, floods and fires. The principles of resiliency planning may also be applied to hazards that have not yet affected the community, such as the potential for a substantial rise in sea level.

The U.S. Department of Homeland Security defines "resilient" as the "*ability of systems, infrastructures, government, business, and citizenry to resist, absorb, recover from, or adapt to an adverse occurrence that may cause harm, destruction, or loss of national significance.*" Resiliency requires having a well-prepared community and good response actions by local government. Local police, fire, emergency medical services, emergency management, public health and medical providers, public works, and other community agencies are generally the first to respond to an emergency or disaster and to provide assistance to the community. Private sector businesses and organizations also play a vital and essential role in the community's response following a disaster.

Education of the public is an important component of efforts to create a more resilient community, and those efforts should focus on increasing the public's awareness of risk levels and specific hazards, and providing guidance on how to be self-reliant after a major disaster. Engaging the public in the resiliency planning process will improve the community's response after a disaster by increasing their ability to be self-sufficient and by knowing what community response efforts will likely be provided during and after an emergency. Community education regarding pre-disaster planning efforts and post-disaster response capabilities should also consider all members of the community, including individuals, families, pets, service providers for people with disabilities, and others with access and functional needs.

The City's Office of Emergency Services (OES) conducts programs to increase the community's awareness of hazards and disaster preparedness. OES programs include: monthly newsletters providing information on hazards that may affect the City and how to prepare for and respond to an emergency; Community Emergency Response Team training; safety education for seniors, children and persons with disabilities; and programs for the Spanish-speaking community. These types of programs are important components of the City's resiliency planning efforts and should be continued and if possible expanded.

For hazards such as earthquakes, fires and floods, evaluating risk and planning for appropriate response and resiliency measures can be achieved, in part, by reviewing the effects of, and responses to past events. Studying previous response actions can illustrate how best to respond to future emergencies. Some potential hazards; however, could be unprecedented and there may be no appropriate response methodology to review and learn from. For example a large earthquake in the Santa Barbara region could damage bridges along U.S. 101 north and south of Santa Barbara, and landslides could close SR 154. Under such a scenario, Santa Barbara could be isolated from assistance and major response efforts by outside agencies for many hours or days.

Sea level rise presents different resiliency challenges as the extent of future sea level changes and predictions of potential consequences are still uncertain. In addition, should a substantial rise in sea level occur, the resulting consequences will likely not happen for many years. An initial assessment of the potential for flooding and inundation impacts to low-lying coastal areas of Santa Barbara due to a rise in sea level is provided by the *Santa Barbra Sea Level Vulnerability Study* (Griggs, 2012). This evaluation indicates that between the present (2012) and around the year 2050, there is a "moderate" probability (risk) of impacts to low-lying coastal areas and the magnitude of those impacts would also be considered to be "moderate." However, over a longer period, such as by the year 2100, the probability of flooding and inundation impacts to coastal areas becomes "very high" if sea level were to rise by approximately four feet as predictions indicate. Under such conditions, the magnitude of impacts from sea level rise is considered to be "high." The uncertainty associated with the timing and extent of future sea level conditions warrants the implementation of prudent response and adaptation planning measures commensurate with anticipated levels of risk during the near- and moderate-term planning horizons.

The City recently adopted a *Climate Action Plan* (2012) that outlines a variety of measures that would reduce risk to residents and important infrastructure resulting from climate change-related effects such as a substantial rise in sea level. Other hazards that could also be influenced by climate change, such as an increase in the frequency and intensity of flooding and wild fire hazards, would be addressed through the continued implementation of existing risk reduction and emergency response efforts and planning programs. If fire and flooding hazards do increase as a result of climate change, existing risk reduction and response programs will take on added importance and could be implemented more often in the future.

As described above, the City of Santa Barbara, as well as Santa Barbara County, California and federal government agencies have devised and implemented a wide variety of emergency planning and response programs that are intended to reduce hazard-related risk, to provide assistance to communities during an emergency, and to aide in the short- and long-term response to a disaster. Local programs, such as the Santa Barbara *Emergency Operations Plan* and the *Multi Jurisdictional Hazard Mitigation Plan* are reviewed and updated regularly to address new planning requirements, provide new information about how hazards may affect the community, and focus on changing risk reduction and emergency response priorities.

A vital aspect to increasing post-disaster resiliency is to minimize the amount of damage that may occur to critical structures and lifeline facilities during an event such as a fire, flood or earthquake. The *Multi Jurisdictional Hazard Mitigation Plan* assists in this effort by identifying City-owned critical facilities and the natural hazards that may affect them. The City-owned facilities and the hazards that may affect the facilities are summarized on Table 1. With the information provided by the *Multi Jurisdictional Hazard Mitigation Plan*, resources can be more effectively allocated to improve safety and hazard resistance at potentially affected facilities.

RELATIONSHIP TO OTHER GENERAL PLAN ELEMENTS AND PLANNING PROGRAMS

General Plan Elements

The Safety Element is one of the seven required elements of the general plan. California Government Code Section 65300.5 requires the general plan and its elements to be "*an integrated, internally consistent and compatible statement of policies…*"

The Safety Element is most closely related to the Land Use and Open Space Elements. The Land Use Element specifies the general distribution of land uses throughout the planning area, and provides standards for population and building density. To minimize hazard exposure risk to the public, the Land Use Element should consider the hazard identification and evaluations provided by the Safety Element. By limiting development density in areas subject to geologic, fire, flooding and other safety hazards, the risk of loss of life, injury and property damage can be reduced. An objective of the Open Space Element is to preserve open space resources for public health and safety, including areas that require special management and regulation due to hazardous or special conditions, such as earthquake fault zones, floodplains, unstable slopes, and high fire risk.

Government Code Section 65302(g)(3) also requires a link between the Safety and Housing Elements. Upon each revision of the Housing Element, the local planning agency is required to review, and if necessary revise the Safety Element to identify new information that was not available during the previous revision of the Safety Element.

Other Local Planning Programs

In addition to the land use planning requirements of the General Plan, a variety of other hazard reduction programs have been adopted and implemented by the City. A brief description of some of these plans and programs is provided below.

Santa Barbara County Multi-Jurisdictional Hazard Mitigation Plan (2011)

This Plan addresses a variety of hazards that have the potential to affect Santa Barbara County and each of the incorporated cities, including: flooding and coastal storm surge, wildfire, earthquakes, landslides and coastal erosion, dam failure and tsunami. The *Multi-Jurisdictional Hazard Mitigation Plan* was prepared with input from each city in the County, interested public, city and county officials, and with the support of the State of California Emergency Management Agency and the Federal Emergency Management Agency.

The emphasis of the *Multi-Jurisdictional Hazard Mitigation Plan* is on the assessment and avoidance of identified risks, implementing loss reduction measures for existing risk exposures, and ensuring that critical services and facilities survive a disaster. The *Multi-Jurisdictional Hazard Mitigation Plan* also promotes compliance with state and federal program requirements, and inter-jurisdictional coordination of disaster preparedness and reduction programs.

The *Multi-Jurisdictional Hazard Mitigation Plan* includes an "Annex" (2011) or section that pertains specifically to each city in the County, including Santa Barbara. The Santa Barbara Annex to the *Multi-Jurisdictional Hazard Mitigation Plan* includes a hazard assessment, a vulnerability assessment that identifies areas of the City and "critical facilities" that may be affected by hazards, and recommended hazard reduction mitigation actions. The Santa Barbara Annex to the *Multi-Jurisdictional Hazard Mitigation Plan* was prepared in 2011 and adopted by the City in 2012. It is anticipated that the Santa Barbara Annex to the *Multi-Jurisdictional Hazard Mitigation Plan* will be updated at a minimum of every five years.

Geology and Geohazards Master Environmental Assessment, Technical Report and Evaluation Guidelines (2009)

These guidelines describe various geology-related hazards that may affect the City and provides maps depicting the location and severity of geologic conditions and hazards in the City. The hazard maps provided by the Geology and Geohazards Technical Report have been included in Safety Element Technical Background Report (Appendix A). The Geology and Geohazards Technical Report also describes geologic conditions that are to be considered when determining what level of site-specific geological investigation should be required for various types of development projects. It is the intent of these guidelines to provide standard procedures for preparing geologic and geohazard technical reports for new development projects.

Wildland Fire Plan (2004)

This Plan provides a fire hazard risk assessment based on various evaluation criteria such as topography, vegetation, building construction, road systems, water supply and Fire Department response times. The Plan also identifies fire hazard zones in the City, describes fire protection philosophies and strategies, and provides goals and policies regarding a variety of hazard reduction issues including fire protection codes and standards, post-fire rehabilitation, evacuation, vegetation (fuel) management and public education.

Local Coastal Program (2004)

This Program, comprised of a certified Land Use Plan and Implementation Plans, implements the California Coastal Act and applies to all areas of the City located within the coastal zone – an area generally within 1,000 feet of the coastline. A separate Local Coastal Program also applies to a portion of the Santa Barbara Municipal Airport and the Goleta Slough. Hazard-related information and policies provided by the updated Safety Element that are applicable to the coastal zone will be incorporated into the City Local Coastal Program and will become effective after certification by the City and California Coastal Commission.

Table 1
City of Santa Barbara Critical Facility Vulnerability Assessment

Critical Facility	Address	Flooding	Wildfire Severity Zone	Earthquake Vulnerability-Groundwater/ Liquefaction	Landslide	Dam Failure Hazard Zone	Tsunami Hazard Zone
Public Works/City Offices	630 and 635 Laguna Street	100-year zone		Moderate/High			
Cater Water Treatment Plant	1150 San Roque Road		Very High				
Ortega Well Treatment Plant	220 E. Ortega Street			Moderate/High			
Ortega Well Treatment Plant	631 Garden Street			Moderate/High			
Sheffield Treatment Plant	605 Mission Ridge Road		Very High				
Public Works	700 Anacapa Street			Moderate/High			
Water Treatment	3111 State Street			Moderate/Moderate		Within Zone	
Public Works	2491 Foothill Road		Very High	Moderate/Moderate			
Tunnel Reservoir	1500 Tunnel Road		Very High				
El Cielito	2410 Stanwood Drive		Very High				
Hope Reservoir	428 Centenella Lane						
Calle Las Caleras	3400 Calle Las Caleras						
Escondido Pump Station	2300 Skyline Way						
Vic Trace	1631 La Coronilla						
Skofield Pump Station	2117 Mount Calvary		Very High				
Public Works	605 Mission Ridge Road		Very High				
Bothin Pump Station	55 Crestview Lane		Very High				
Desalination Plant	525 E. Yanonali Street			High/High			Within Zone
El Estero WWTP	520 E. Yanonali Street			High/High			Within Zone
Skofield Park	1819 Las Canoas Road		Very High				
Stearns Wharf	219 Stearns Wharf	100-year zone		High/High			
Airport	500 Fowler Road	100-year zone		High/High			Within Zone
Harbor	various	100-year zone		High/High			Within Zone
City Hall	735 Anacapa Street						

Table 1
City of Santa Barbara Critical Facility Vulnerability Assessment

Fire Station No. 1	121 W. Carrillo Street						
Fire Station No. 2	819 Cacique Street	100-year zone		Moderate/Moderate			
Fire Station No. 3	415 Sola Street			Moderate/High			
Fire Station No. 4	19 Ontare Road			Moderate/Moderate			
Fire Station No. 5	2505 Modoc Road			Moderate/Moderate			
Fire Station No. 6	1801 Cliff Drive			Moderate/Moderate			
Fire Station No. 7	2411 Stanwood Drive		Very High				
Fire Station No.8	40 Hartley Place	100-year zone		High/High			
Police Department Hdqtrs.	215 E. Figueroa Street						
Admin Well Corp.	402 E. Ortega Street	100-year zone		Moderate/High			
Recreation	1232 De La Vina Street						
Recreation	100 E. Carrillo Street						
Westside Community Center	629 Coronel Place			Moderate/Moderate			
Franklin Community Center	1136 E. Montecito Street			Moderate/Moderate			
Recreation	620 Laguna Street	100-year zone		Moderate/High			
Public Works	State St./Las Positas Rd.			Moderate/Moderate		Within Zone	
Marinas 1-4	Harbor			High/High			Within Zone
Navy Pier	Harbor			High/High			Within Zone
Ortega Well	Ortega St./Salsipuedes St.	100-year zone		Moderate/High			

Source: Modified from *City of Santa Barbara Annex to Santa Barbara County 2011 Multi-Hazard Mitigation Plan*

KEY

- Low risk
- Moderate risk from high groundwater/moderate risk from liquefaction
- Moderate risk from high groundwater/high risk from liquefaction
- High risk

Airport Land Use Plan (1993)

This Plan is administered by the Santa Barbara County Association of Governments. The Airport Land Use Plan establishes "clear zones" and "approach zones" around the Airport's runways, and provides land use requirements and land use population density requirements for those zones to protect people and property in the event of an aircraft accident.

Harbor Master Plan (1996)

This Plan is an appendix to the City's Local Coastal Program and provides background information and policies pertaining to the operation of the Harbor and its related facilities.

Airport Master Plan

The Federal Aviation Administration requires airports to maintain a master plan that is generally updated every five to ten years. The Aviation Facilities Plan has guided development at the Santa Barbara Airport for the past ten years and will be superseded by a new *Airport Master Plan*. The Master Plan is being prepared by the City and will address a variety of airport-related operation issues.

City Climate Action Plan (2012)

This Plan addresses a variety of climate change-related issues, including potential hazards such as sea level rise, flooding, and sea cliff retreat.

City Codes and Ordinances

The City has adopted a variety of regulatory programs that are intended to reduce the effects of hazards on the community. Several of these programs are described below.

The City Building Code

Municipal Code Chapter 22.04) adopts with amendments the requirements of the California Building Code (Title 24 of the California Code of Regulations). The Building Code contains provisions to address current standards related to the development of earthquake-resistant structures, and to address other seismic, geologic and soil conditions.

The Seismic Safety Ordinance

(Municipal Code Chapter 22.18) provides standards for the retrofit of specified hazardous buildings, typically buildings generally referred to as unreinforced masonry buildings. The purpose of the Ordinance is to reduce the potential for damage or collapse of buildings during an earthquake.

The Flood Plain Management Code

(Municipal Code Chapter 22.24) provides requirements for buildings located within designated 100-year floodplains. The purpose of the Code is to minimize public and private losses due to flood conditions.

The City Fire Code

(Municipal Code Chapter 8.04) adopts with amendments the requirements of the International Fire Code and the California Fire Code (Title 24 of the California Code of Regulations). These codes provide specific provisions for building construction and vegetation management to reduce the risk of fire hazards.

LIMITATIONS

The Safety Element provides a general evaluation of public safety hazards that have the potential to affect the City of Santa Barbara. The Safety Element's identification and evaluation of hazards is based on the review of literature that was readily available at the time of the Element's preparation. No site-specific evaluations were conducted to assess the effects of hazards on individual properties or projects. The maps provided by the Safety Element depict the general areas that may be affected by hazards, and should not be interpreted as to precisely define hazard areas. The Element's maps should be used as an important reference during the land use evaluation and decision-making process, such as guiding decisions regarding when detailed site investigations should be required.

The Santa Barbara Community

GEOGRAPHIC AREAS

For the purposes of the Safety Element, the City of Santa Barbara can be described as consisting of eight major geographical areas: the Mesa, Waterfront, Eastside, Riviera, Downtown, Upper State, Westside and Las Positas areas. The locations of each of these geographic areas are depicted on Figure 1. A brief description of each area is provided below, and more detailed information about individual neighborhoods within each area is provided by the Land Use Element of the General Plan.

Mesa

The Mesa area is located in the southern portion of Santa Barbara and is bordered on its northern side by a steep slope that has been uplifted along the Mesa Fault and reaches a maximum elevation of about 400 feet. Due to the steep gradient of this slope, along with the presence of oak woodland and other native vegetation, this area has a high fire hazard designation. The remainder of the Mesa area is an elevated marine terrace that slopes moderately to gently southward until it terminates at the Pacific Ocean along a steep coastal bluff. Due to various geologic conditions, wave action and other factors, the sea cliffs erode landward at various rates, but in general at approximately four to 12 inches per year.

Waterfront

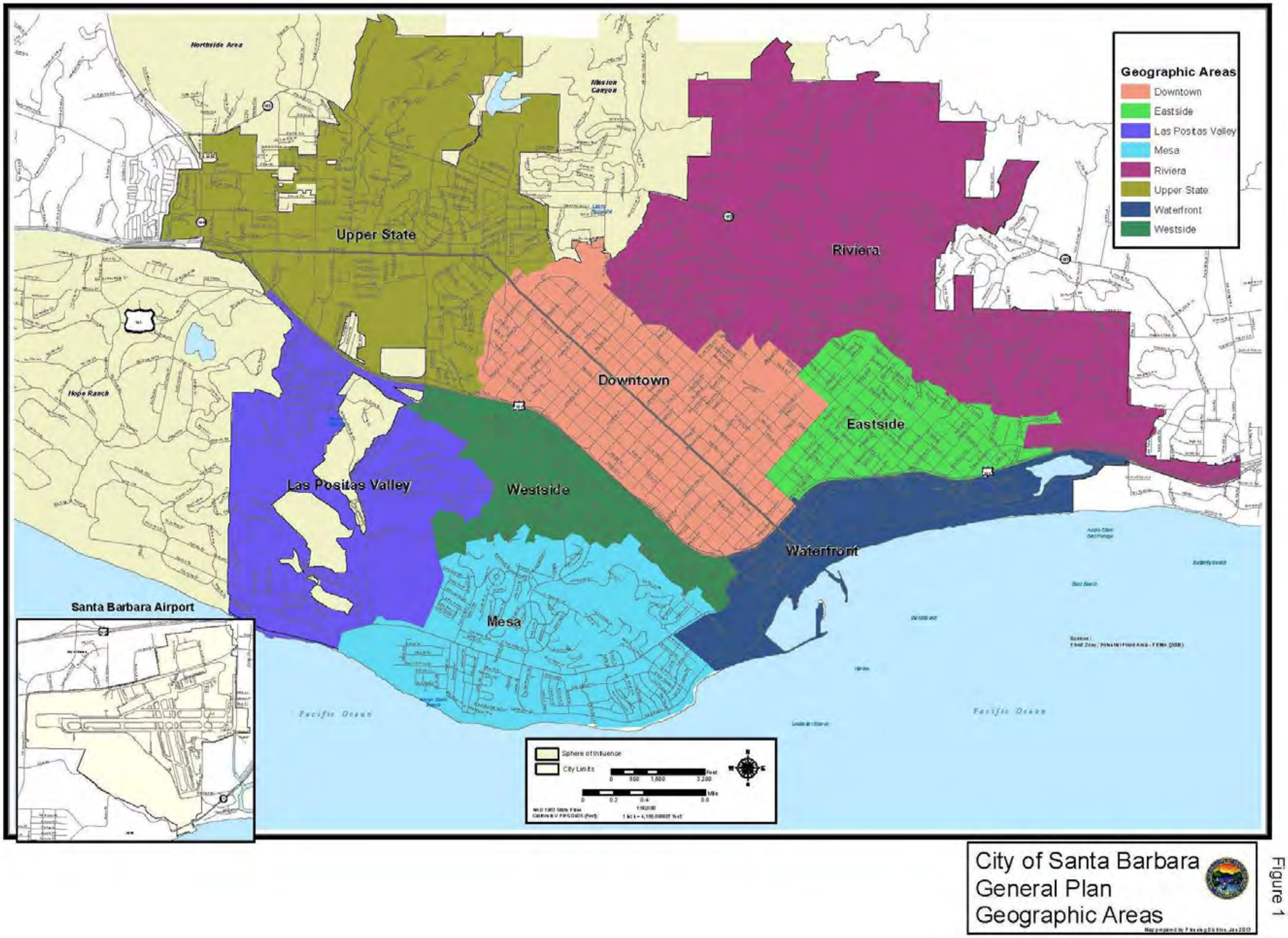
The Waterfront geographical area is a low-lying coastal portion of the City. Much of the level area south of Shoreline Drive was created in the early 1930's by sand that was trapped soon after the Harbor breakwater was completed. Portions of the Waterfront area are located within the 100-year floodplains of Mission Creek and Sycamore Creek, and other areas are located on land that was formerly an estuary (known as "El Estero") that extended northward to about Ortega Street. The Estero was filled during the 1920's and 1930's. The Waterfront area is the part of the City that has the highest potential to be affected by a tsunami or by a global climate change induced rise in sea level.

Eastside

The Eastside is a generally level area and a large portion of this area was also part of the historic Estero that was filled during the 1920's and 1930's. The lower portion of Sycamore Creek extends across the Eastside area.

Riviera

The slopes that form much of the Riviera are located along a topographic feature known as Mission Ridge, which has been raised over geologic time by upward movement along the Mission Ridge fault zone. The northernmost portions of the Riviera are located along the foothills of the Santa Ynez Mountains and have a maximum elevation of about 1,200 feet.


Geographic Areas
Downtown
Eastside
Las Positas Valley
Mesa
Riviera
Upper State
Waterfront
Westside
Upper State
Riviera
Downtown
Eastside
Westside
Las Positas Valley
Waterfront
Mesa
Santa Barbara Airport
Northside Area
Mission Canyon
Hope Ranch
Pacific Ocean
Pacific Ocean
Sphere of Influence
City Limits
City of Santa Barbara
General Plan
Geographic Areas
Figure 1

Due to the presence of steep slopes and complex geology, areas with active landslides are present in the Riviera area. Some portions of the Riviera area have a combination of steep slopes, abundant native vegetation and narrow winding roads, which contribute to a high wildfire hazard risk. Some neighborhoods in the Riviera area have been affected by recent wildfires, including the Sycamore Canyon Fire (1977), Tea Fire (2008) and Jesusita Fire (2009).

Downtown

The Downtown area includes Santa Barbara's commercial core, which sustained substantial damage during the 1925 Santa Barbara earthquake. Cottage Hospital is located in the northern portion of the Downtown area and was recently reconstructed to meet modern seismic building codes for hospitals. Mission Creek is located along the western and southern edges of the Downtown area.

Upper State

The topography of the Upper State area varies considerably and includes neighborhoods with relatively level topography and areas located along the lower foothills of the Santa Ynez Mountains. The northern portion of the Upper State area includes neighborhoods that have been designated as having a high fire hazard risk and suffered fire-related damage during the 2009 Jesusita Fire. Several creeks are located in the Upper State area, including San Roque, Arroyo Burro, Barger Canyon and Cieneguitas Creeks. The Lauro Reservoir is located north of and adjacent to the Upper State area

Westside

The Westside area is generally level; however, the southern border of this area abuts the steep slope that forms the northern edge of the Mesa. The Mesa fault extends through much of the Westside area.

Las Positas

Arroyo Burro Creek extends through the Las Positas area from north to south, and the creek has formed the Las Positas Valley, which has steep hillsides on its eastern and western sides. Areas of native vegetation on the steep slopes have resulted in much of the Las Positas area being designated as a high fire hazard zone. Also due to steep slopes, geologic and soil conditions, the undeveloped steep slopes on the western portion of the valley are susceptible to landslides.

Santa Barbara Municipal Airport

The Airport is an incorporated area approximately eight miles west of the City and is adjacent to the City of Goleta and the University of California at Santa Barbara. Much of the airport was originally constructed during World War II in conjunction with the development of a Marine Corps Air Station, and was developed by filling a portion of the Goleta Slough with fill material derived from nearby Mescalitan Island. The island was a formerly prominent feature located in the slough, but is now a small hill located between the Airport and State Route 217.

Geologic and Seismic Hazards

Geologic conditions in the Santa Barbara region are complex, and movement along regional and local faults over geologic time has shaped the Santa Barbara landscape. Geologic and seismic forces continue to affect Santa Barbara and have the potential to result in adverse to catastrophic effects on development in the City. When geologic and seismic processes and conditions have the potential to affect urban development, those conditions are often referred to as "hazards."

In conjunction with the City's planning and development review functions, seismic and geologic conditions are evaluated to assess the vulnerability of new and existing development to various hazards, and to identify ways to minimize risk to life, safety and property. One of the goals of the Safety Element is to assist and facilitate this review process. A brief description of the geologic and seismic hazards that may affect Santa Barbara is provided below. More detailed information and maps for each of the identified hazards is provided in the *Safety Element Technical Background Report* (Appendix A).

FAULT RUPTURE

A fault is a fracture in the earth's crust along which one side has moved relative to the other side. Movement along a fault can occur suddenly during an earthquake or very slowly in a process known as "creep." Fault rupture occurs when movement along a fault displaces or deforms of the ground surface. Not all earthquakes result in fault rupture-related impacts, and when impacts do occur, it is generally as a result of large earthquake events. Ground rupture generally results in a small percentage of the total damage caused by an earthquake, but structures affected by ground rupture are usually severely damaged. Figure 6, Fault Hazard Zones, of the *Safety Element Technical Background Report* (Appendix A) depicts the location or suspected location of the faults and fault systems in Santa Barbara that are identified as "apparently active" and present the highest risk of resulting in fault rupture impacts. A fault is considered to be "active" when there is evidence of fault movement occurring over the past 11,000 years. The apparently active faults depicted on Figure 6 include the Mission Ridge, Lagoon and Rocky Nook fault system, the More Ranch fault, and the Mesa fault. Other faults in the City depicted on Figure 6 are identified as "potentially active," which means that there is no evidence of movement along the faults between the last 11,000 to two million years.

Offset of the ground surface caused by fault rupture can range from several inches to tens of feet, therefore, it is typically not practical or feasible to reduce damage to structures caused by ground rupture through engineering design. The avoidance of areas that may be affected by ground rupture is generally the most appropriate risk reduction measure. This hazard reduction strategy, however, may not be feasible for linear structures such as roads and pipelines.

The *Geology and Geohazards Technical Report* describes methodologies to be used to evaluate the potential fault rupture impacts. Evaluation requirements vary depending on the type and use characteristics of a proposed building, as well as site-specific conditions. Reducing the risk of fault rupture impacts to new buildings is generally achieved by conducting site-specific investigations to determine the location and characteristics of a fault, and providing an adequate setback from the fault or fault zone to minimize the risk of impacts should movement along the fault occur in the future.

GROUND SHAKING

Energy released by movement along a fault radiates outward through the ground in the form of earthquake waves. As those waves pass through an area, they produce the ground shaking effects that are the predominant cause of earthquake-related damage. The severity of damage caused by ground shaking is controlled by many factors, including the magnitude of the earthquake, the distance to the location where the fault movement occurred, how long the ground shakes and the speed at which it shakes, local geologic conditions, and the design of affected buildings and structures.

Santa Barbara has been affected by ground shaking on numerous occasions during historic times. The most notable of these events was the earthquake of 1925, which caused extensive damage throughout much of the Downtown area. Additional information about the 1925 earthquake is provided on page 19

The United States Geological Survey uses various computer models to estimate the probability of a certain area being affected by an earthquake of a given magnitude. It has been estimated that there is a 60-80 percent probability that the Santa Barbara area will be affected by a magnitude 5.0 or greater earthquake in the next 50 years, and that there is a 50-60 percent chance of a 6.0 magnitude earthquake and a 15-20 percent chance of 7.0 magnitude earthquake occurring in the next 50 years.

Ground shaking-related hazards are minimized primarily through the implementation of modern building codes. These regulations specify design standards for general structures, as well as increased standards for "essential facilities" such as hospitals, schools and certain public facilities. The City has also implemented programs to reduce hazards associated with the presence of unreinforced masonry buildings, which present a high risk of collapse during strong earthquakes.

1925 SANTA BARBARA EARTHQUAKE

The Santa Barbara Mission was damaged by the 1812 earthquake and rebuilt by 1820. The 1925 earthquake caused the extensive damage shown in this photograph.

The California Hotel opened four days before the earthquake and experienced heavy damage to brick walls that were not securely tied to the building. Some occupants left the building by lowering themselves to the street using bed sheets.

Many of the unreinforced masonry buildings along State Street were damaged or destroyed.

The earthquake occurred on June 29, 1925 at 6:44 a.m. and was caused by movement on a fault located in the Santa Barbara Channel. Santa Barbara had a population of about 25,000 in 1925, and the earthquake resulted in 13 fatalities. The number of casualties was probably reduced due to the early hour that the earthquake occurred.

No foreshocks were reported before the earthquake, however a water system pressure gauge recording card showed disturbances beginning at 3:27 am, which were likely caused by foreshocks. Then City Manager Herbert Nunn reported noticing a strong smell of oil at the beach soon before the earthquake occurred.

It was reported that strong ground shaking caused by the earthquake lasted 19 seconds, and four strong aftershocks occurred within 20 minutes after the quake. Additional aftershocks occurred for a year after the main earthquake. After the major shaking subsided, many of the buildings in the City's business district were destroyed or severely damaged. Unlike the 1906 San Francisco earthquake where much of the damage to the city was caused by the subsequent fire, gas and electrical power to Santa Barbara was turned off soon after the earthquake. Since no fires occurred after the Santa Barbara earthquake, the destructive force of the groundshaking could be clearly seen.

Most of the homes in the City experienced only minor damage, such as broken brick chimneys. Historian Walker A. Tompkins noted that after the earthquake one thing became obvious, "*the quake destroyed the shoddy and left the substantial.*" Newer buildings in the City that survived the earthquake included the Lobero Theater, Masonic Temple, the Daily News Building (the News Press Building), City Hall, the El Paseo and Presidio complexes, the main post office at State and Anapamu Streets (now the Art Museum), and Santa Barbara High School.

After the earthquake, the City embarked on a major reconstruction effort. As part of this program, policies were adopted to promote the construction of buildings in the Spanish Colonial Revival style. As a result, the earthquake had a substantial effect on the appearance of Santa Barbara today.

Photo Source: UCSB Institute for Crustal Studies

LIQUEFACTION

Liquefaction is a temporary loss of soil strength that can occur during moderate to large earthquakes. Liquefied soil will have a substantial loss of bearing strength, which may cause buildings in affected areas to settle or tilt. The resulting structural damage can range from minor to complete failure. Depending upon buoyancy differences between the liquefied soil and lightweight or unanchored underground structures such as pipelines, underground structures may float upward to the ground surface.

Three conditions must be present for liquefaction to occur: affected soils must be comprised of granular material such as sand; the soil must be saturated by groundwater; and the soil must be relatively loose. Of these three conditions, the saturation of soil by groundwater is the condition that has the potential to change over time, particularly in response to seasonal fluctuations in groundwater levels. Areas with shallow groundwater have a higher risk for liquefaction to occur, and in general, liquefaction risk is considered to be low when groundwater levels are more than about 60 feet below the ground surface. In areas with groundwater shallower than 60 feet, the liquefaction hazard may or may not be present, depending on the characteristics of the soil.

Potential liquefaction hazard risk zones in the City are depicted on Figure 9, Potential Liquefaction Hazard Zones, of the *Safety Element Technical Background Report* (Appendix A). This map provides an update to the liquefaction hazard map provided by the *Geology and Geohazards Technical Report* and was prepared by identifying areas of the City with soil and groundwater characteristics that could contribute to an elevated risk of liquefaction. The *Safety Element Technical Background Report* (Appendix A) provides additional information regarding how the Safety Element liquefaction hazard map was prepared.

Areas of the City with the highest liquefaction risk generally include low-lying portions of the Waterfront, Eastside, Downtown, Westside and Las Positas areas of the City, as well as the Airport area. Many of the areas with a high liquefaction potential are located within the boundaries of the estero that was formerly located in the lower portions of the City and was filled during the 1920's and 1930's.

Liquefaction is a mitigable hazard and its effects on structures can be minimized through a variety of project site modifications and/or building designs. The *Geology and Geohazards Technical Report* describes methodologies that are used to assess site-specific liquefaction hazards. Based on the results of site-specific investigations, appropriate site modifications, building foundation, and design measures can be implemented to minimize and risk of liquefaction and its associated effects.

TSUNAMI

A tsunami is a series of waves generated by a vertical displacement of the ocean floor, most commonly as a result of fault movement. As the waves enter shallow water along the coast, they slow down and the wave height increases. The waves may rise to several feet in height, although in rare cases may reach heights of tens of feet. The height of the waves will be influenced by many factors, including near-shore bathymetry (underwater topography), shape of the coastline, and tide conditions.

Tsunamis with the potential to affect Santa Barbara may be generated by an earthquake that occurs locally, such as in the Santa Barbara Channel, or by a large earthquake that occurs at a distant location. The threat of a locally-generated tsunami affecting Santa Barbara is relatively low based on the low recurrence interval for large earthquakes originating in the Santa Barbra Channel. The City recently experienced relatively minor tsunami-related damage to facilities in the Harbor as a result of large earthquakes off the Coast of Chile in 2010 and Japan in 2011. Additional information about the recent tsunami events in Santa Barbara is provided on page 22.

Figure 11, Tsunami Hazard Zones, of the *Safety Element Technical Background Report* (Appendix A) depicts the location of the low-lying coastal areas of the City that may be susceptible to tsunami-related impacts. Portions of the City most likely to be susceptible to tsunami-related damage are generally located in the Waterfront and Airport areas.

Programs have been implemented at the federal, state and local level to identify tsunami-related hazards, reduce the risk of injury and damage caused by tsunamis, and to educate the public about tsunami-related hazards. At the local level, Santa Barbara was designated by the National Weather Service as a TsunamiReadyTM community in 2012. To be recognized as TsunamiReady, communities must have a 24-hour warning system, have more than one method to receive tsunami warnings and to alert the public, promote public readiness, and develop a tsunami response plan.

SEICHE

A seiche (pronounced saysh) is a wave or series of waves in an enclosed or semi-enclosed body of water such as a lake, reservoir, or harbor that can be generated by earthquake-related groundshaking, a landslide into the water body, wind, or a tsunami. If the seiche wave overtops the edge of the water body, it can run up onto adjacent land areas and result in property damage. The Lauro Reservoir and the Harbor are the water bodies in the City most susceptible to a seiche hazard. Providing appropriate setbacks between structures and areas that could experience seiche-related inundation is an effective method to reduce the risk of damage from this hazard.

LANDSLIDES

Landslides occur on sloping ground when the weight of the material that comprises the slope and the weight of objects placed on the slope exceed the strength of the slope material. The down-slope movement of earth material is part of the continuous and natural process of erosion; however, the stability of a slope can be adversely affected by a wide variety of factors, such as by adding water to a slope. Other factors that can decrease the stability of a slope include erosion of the toe of a slope, which removes support for overlying material; placing additional weight, such as structures, on the slope; changes to the slope's configuration by grading; earthquake-related groundshaking; and/or fires that remove vegetation from the surface of the slope.

RECENT TSUNAMI EVENTS IN SANTA BARBARA

Tsunami waves are often preceded by the retreat of ocean water along the coast. This picture shows the drop in water levels at the Santa Barbara Harbor before waves generated by the 2011 Japan earthquake arrived.

This picture also shows the drop in water level within the Harbor before the arrival of tsunami waves generated by the 2011 Japan earthquake.

As a result of the March 11, 2011 magnitude 9.0 earthquake off the coast of Japan, the West Coast/Alaska Tsunami Center issued a tsunami advisory for the California coast, and tsunami waves occurred in Santa Barbara about 11 hours after the earthquake occurred. Wave run up in the Harbor was about three feet in height, and the waves damaged a crane, bait barge and several boats. Total damage caused by the tsunami waves was estimated to be about $70,000.

On February 27, 2010, a magnitude 8.8 earthquake occurred along the central coast of Chile and a tsunami advisory was issued for California. Tsunami waves of about three feet in height were reported by tide gauges in the Santa Barbra Channel. In Santa Barbara, tsunami waves resulted beach erosion and the displacement of buoys. Tsunami wave surges from this event lasted more than 20 hours.

Photo source: www.sbwatertaxi.com

The *Geology and Geohazards Technical Report* identified landslide-prone areas of the City based on the results of previous landslide identification and mapping efforts. Figure 13, Slope Failure Hazard Zones, of the *Safety Element Technical Background Report* (Appendix A) depicts identified landslide hazard risk areas throughout the City and categorizes risk as "Very Low," "Low," "Moderate," and "High." Areas of the City designated as having a "High" landslide risk are considered to be naturally unstable and subject to slope failure even without being modified by grading or other development-related processes. Areas with a "High" landslide risk are generally located on: the Mesa north of Cliff Drive (SR 225); the steep slopes along the west side of the Las Positas area; the coastal bluffs in the southwestern part of the City; and much of the Riviera area. The Riviera area includes two areas of recent landsliding that are referred to as the "Conejo Road Landslide" and the "Canon View Road/Sycamore Canyon Landslide." Movement of slopes in these areas apparently began in response to heavy "El Niño" rain events in 1982-83. Additional slope movement occurred in January 2005 when heavy rains resulted in additional slope movement that resulted in the closure of a two-mile segment of State Route 144 (Sycamore Canyon Road), destroyed eight homes, and damaged other homes and structures.

The *Geology and Geohazards Technical Report* provides guidance for when site-specific slope stability investigations should be prepared for various types of development projects based on the project's location and the landslide risk designation. The objective of the investigations is to evaluate existing slope stability conditions and to determine if project-related modifications to a slope would have the potential to result in on- or off-site stability impacts. If necessary, the evaluation should also identify ways that the project and/or proposed changes to a slope can be modified to minimize stability-related impacts.

SEA CLIFF RETREAT

Sea cliff retreat is an erosion- and landslide-related hazard that affects the ocean bluffs located along the City's coast. The coastal bluff environment is very dynamic and can present great variation in the composition, structure and strength of the rocks and soil that form the bluffs. These conditions result in hazard assessment and risk reduction challenges not generally associated with natural or manufactured slopes located in inland areas.

Sea cliff retreat is a continual, natural process caused by both marine and terrestrial erosion processes that cause the face of the ocean bluffs to "retreat," or move landward. Wave action is the predominant erosional process as waves can erode the base of the cliff and remove support for overlying cliff material, which increases the potential for landslides to occur. Where beaches are wide and waves seldom reach the base of the cliff, terrestrial processes, such as erosion by stormwater runoff over the face of the bluff, can be the dominant cause of sea cliff retreat.

Ocean bluffs may appear to go unchanged for many years as erosion of the cliff occurs slowly, generally by the gradual loss of bluff material. Conversely, extensive losses of bluff material may occur suddenly due to large landslides that occur when the stability of the slope is adversely changed. The addition of water to the bluff during heavy rainfall events is a common trigger for landslides. Although large slope failures occur infrequently, these episodic events and the associated loss of material substantially influence the overall average rate of bluff retreat. Rates of sea cliff retreat can be delayed or accelerated by human actions. Seawalls and revetments can slow sea cliff retreat at a specific site, but can also result in increased beach sand erosion and accelerated bluff erosion adjacent to the protective structure.

There are approximately four miles of coastal bluffs within the City limits, including the cliffs that form the southern boundary of the Mesa neighborhoods, and the cliffs adjacent to the Clark Estate and the Santa Barbara Cemetery. The height of the sea cliffs gradually decrease from west to east, with cliffs of about 150 feet located in the Douglas Family Preserve area; 100 feet in the West Mesa neighborhood; and about 50 feet along Shoreline Park in the East Mesa neighborhood. The coastal bluffs are about 50 feet in height adjacent to the Cemetery in the East Beach neighborhood of the City.

Several large landslides have affected the Santa Barbara ocean bluffs in the recent past. On February 14, 1978, the El Camino de la Luz landslide encompassed an area approximately three acres in size and resulted in the destruction of two homes. On January 25, 2008, a landslide affected the bluff in Shoreline Park. This landslide extended 70 feet along the top of the cliff and moved the bluff edge landward 38 feet. Other landslide areas along the bluffs adjacent to the East and West Mesa neighborhoods are depicted on Figure 13, Slope Failure Hazard Zones, of the *Safety Element Technical Background Report* (Appendix A).

Several different studies of sea cliff retreat rates have been conducted in the Santa Barbara area. One study evaluated erosion rates over a 70-year period and determined that the highest retreat rate was approximately 12 inches per year, while the average erosion rate was eight inches per year. The *City of Santa Barbara Sea Level Rise Vulnerability Study* (Griggs, 2012) reports that based on a review of historical aerial photographs, average long-term sea cliff retreat rates in Santa Barbara ranged between six and 12 inches per year. Another study identified average sea cliff retreat rates of about four to 18 inches per year for cliffs adjacent to the West and East Mesa neighborhoods, and just under six inches per year for the cliffs adjacent to the Clark Estate/Santa Barbara Cemetery.

The estimated rates of sea cliff retreat vary due to local differences in the composition and structure of the bluffs, the effects of bluff-top development, and barriers located at the base of the bluffs such as cobbles, boulders, or rip rap. Although there can be a wide variation in the rate of retreat at individual sites and bluff retreat generally occurs in an episodic manner, the average rate of retreat for the Santa Barbara bluffs when measured over an extended period of time is historically about six to 12 inches per year. At that average rate, the City's ocean bluffs could be expected to retreat by approximately 10-20 feet over the next 20 years, and approximately 45 to 90 feet by 2100.

The *Geology and Geohazards Technical Report* identifies areas adjacent to the current bluff edge that may be affected by sea cliff retreat over the next 75 years. A 75-year timeframe was used because this is the period of time used by the City as the expected design life of new structures, and if sea cliff retreat were to threaten a structure that is at least 75 old, the structure would likely be obsolete and ready for demolition for reasons other than encroaching erosion. Based on the estimate of 12 inches of sea cliff retreat per year, for planning purposes it could be expected that the bluff edge that existed in 2013 will retreat landward by approximately 75 feet over the next 75 years (2088). Figure 14, 75-Year Sea Cliff Retreat Line, of the *Safety Element Technical Background Report* (Appendix A) depicts the bluff-top areas of the City that could be affected by sea cliff retreat over the next 75 years. This figure presents a theoretical bluff retreat area that is to be used for planning purposes only. Actual rates of sea cliff retreat and the area that may be affected over the next 75 years will vary considerably due to site-specific geologic and other conditions.

An expected consequence of climate change caused by increasing concentrations of greenhouse gases in the Earth's atmosphere is a rise in sea level. As sea level rises, ocean bluffs will be more vulnerable to wave-related erosion, which is expected to result in an increase in existing sea cliff retreat rates. There is substantial variation in predictions of future increases in sea level, particularly for conditions between 2050 and 2100. The *City of Santa Barbara Sea Level Rise Vulnerability Study* concludes that there is a "moderate" potential for sea cliff retreat rates to increase to approximately 12-24 inches per year over the short- to intermediate-term (2012 to 2050), and a "high" or "very high" probability for such increases over the intermediate- to long-term

(2050-2100). If sea cliff retreat rates were to increase as projected, Santa Barbara could experience up to 80 to 160 feet of erosion landward of the present cliff edge by the year 2100.

The *Geology and Geohazards Technical Report* indicates that a site-specific sea cliff retreat evaluation should be prepared if habitable structures, commercial/industrial buildings, essential facilities, and other improvements are proposed to be located seaward of the sea cliff retreat line depicted on Figure 14 of the *Safety Element Technical Background Report* (Appendix A), or within 50 feet of the bluff edge, whichever is greater. The required sea cliff retreat evaluation study should comply with sea cliff retreat evaluation requirements of the California Coastal Commission, which are provided in Appendix B of the *Safety Element Technical Background Report*. In summary, the Coastal Commission requires sea cliff retreat evaluations to include several analysis steps to determine the location of the bluff edge; evaluate the stability of the bluff at the project site; identify appropriate long-term erosion rates to evaluate sea cliff retreat rates at the project site and to identify a 75-year erosion setback line; and if necessary, identify a structure setback factor of safety.

SOIL EROSION

Soil erosion occurs when wind, water, or ground disturbances cause soil particles to move and deposit elsewhere. Numerous conditions influence the susceptibility of soil to the effects of erosion, although the characteristics of the soil, vegetative cover and topography are important factors. The removal of vegetation by construction activities or wildfire can result in a substantial increase in erosion rates. Increases in soil erosion rates can result in increased sediment loads in receiving waters, which can adversely affect water quality and biological resources.

Potential soil erosion hazard areas in the City were identified by the *Geology and Geohazards Technical Report* as ranging from “Very High” to “Slight.” The identified hazard zones are depicted on Figure 15, Erosion Potential Hazard Zones, of the *Safety Element Technical Background Report* (Appendix A). In general, areas with a higher erosion hazard potential are located in hillside and sloping areas of the City. Numerous federal, state and local regulatory programs have been enacted to reduce the potential for erosion-related hazards.

EXPANSIVE SOIL

Expansive soils will expand when wet and shrink when they become dry. Water that causes the soil to swell may be derived from precipitation, irrigation, or other moisture sources. Repeated cycles of shrinking and swelling can cause building foundations, walls, ceilings, and floors to crack, and windows and doors to warp so that they do not function properly. Differential shrinking and swelling can also damage surface improvements such as roadways and sidewalks.

Soils located in the City that present a potential shrink/swell hazard were identified by the *Geology and Geohazards Technical Report* as ranging from “High” to “Very Low,” and are depicted on Figure 16, Expansive Soil Hazard Zones, of the *Safety Element Technical Background Report* (Appendix A). In general, areas that are underlain with soils that have a “High” shrink/swell potential are located throughout the City, but predominately in the Downtown, Mesa, and hillside areas in the northern and western portions of the City. The impacts of expansive soil hazards can be addressed if considered early in a development project’s design, and the *Geology and Geohazards Technical Report* provides recommendations regarding the evaluation of potential expansive soil hazards at development project sites.

RADON

Radon is an invisible and odorless radioactive gas that is created by the decay of uranium and thorium that is naturally present in rocks and soils. Breathing air with elevated levels of radon gas can result in an increased risk of developing lung cancer. Radon gas can move from the soil and into buildings through cracks in slabs or basement walls, pores and cracks in concrete blocks, and openings around pipes. Since radon enters buildings from the adjacent soil, concentrations of the gas are generally highest in basements and in ground floor rooms. While all buildings have some potential for elevated radon levels, buildings located on rocks and soil containing elevated levels of uranium or thorium will have a greater likelihood of having elevated radon concentrations. The U.S Environmental Protection Agency and the California Department of Public Health recommends that individuals avoid long-term exposures to radon concentrations above 4 picocuries per liter (pCi/L).

Areas of the City that have a moderate to high potential for elevated radon concentrations were identified by the *Geology and Geohazards Technical Report* and are depicted on Figure 17, Radon Hazard Zones, of the *Safety Element Technical Background Report* (Appendix A). Areas designated as having a "High" or "Moderate" radon potential are generally located in areas underlain by the Rincon or Monterey Formations, or soils derived from those formations. In general, areas designated as having a "High" or "Moderate" risk potential are located in the upper elevations of the Riviera and Upper State Street area, and portions of the Mesa and Las Positas areas. A common method to minimize the potential for exposure to radon is to install a soil depressurization system that uses a fan and ventilation pipes to create a vacuum below the building. Passive ventilation systems that do not rely on the use of a fan can be installed in new construction. Sealing foundation cracks, pipe penetrations and utility channels can also be an effective measure to reduce indoor radon concentrations.

HIGH GROUNDWATER

High groundwater is a hazard that can have an adverse effect on building construction, roads, storage tank installation, utility installation, and other projects with structural elements that penetrate the subsurface. Buildings and other facilities in areas with high groundwater can be subjected to moisture intrusion, and in some cases, tremendous buoyancy forces that may push up on the structure, potentially causing structural offsets at the ground surface or otherwise causing extensive damage. In general, groundwater within 15 feet of ground surface can create a nuisance and can require special structure design to address buoyancy and moisture intrusion.

Areas of the City that have the potential to be affected by high groundwater are depicted on Figure 18, Shallow Groundwater Hazard Zones, of the *Safety Element Technical Background Report* (Appendix A). In general, areas of the City that have the potential for high groundwater-related hazards include low-lying portions of the Waterfront, Eastside, Downtown, Westside, the Airport and areas located adjacent to the major creeks in the City. While certain areas have been identified as having the potential to be affected by high groundwater levels, it should be recognized that there can be substantial variability in groundwater levels at a particular site seasonally, over time, and due to climatic conditions.

Fire Hazards

This section of the Safety Element provides a description of the two types of fire hazards that have the potential to affect Santa Barbara: fires that occur in wildland areas and structure fires. More detailed information regarding fire-related hazards and their effects on the City is provided in the *Safety Element Technical Background Report* (Appendix A).

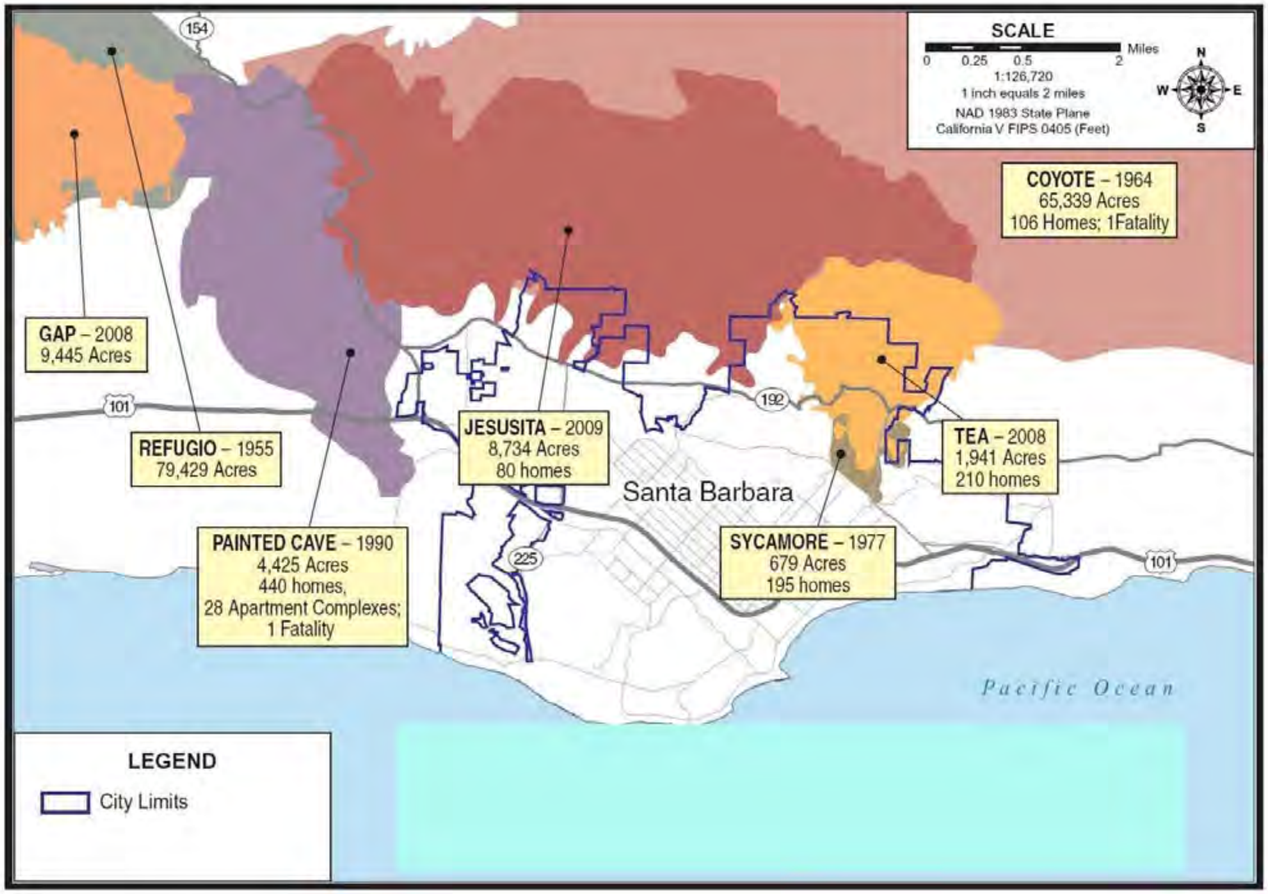
WILDLAND FIRE HAZARDS

Wildland fires are a natural process that can have ecological benefits to the long-term vitality of chaparral and other types of habitat. However, wildland fires can result in a multitude of adverse effects on the built environment, including the potential for loss of life, damage or destruction of public and private structures, loss of personal property, damage to infrastructure systems, and damage to recreation facilities and open space areas. Wildland fires can also result in the loss of hillside vegetation over extensive areas, which can result in a variety of adverse post-fire effects. The loss of protective vegetation can result in substantial increases in stormwater runoff, erosion and sedimentation, and can substantially increase the potential for and severity of landslides, mudslides and downstream flooding. A fire-related increase in these hazards may impact areas not directly affected by the fire and may result in extensive damage to downstream homes, roads, debris basins and other drainage and utility infrastructure, the impairment of water quality, and adverse impacts to aquatic habitats.

A wildland fire that occurs in the vicinity of urban development is often referred to as a "wildland-urban interface" fire. Wildland-urban interface zones are often designated as having a high wildfire hazard potential due to a combination of factors that increase the risk of a wildland fire. Property owners can implement a variety of construction and vegetation management practices to reduce the potential for wildfire-related damage, but must also accept the risk associated with living in a high fire hazard environment.

Wildland fires have been a significant part of Santa Barbra's history. Between 1964 and 2012, seven major wildfires have occurred in the Santa Barbara "front country," which is the area along the south-facing slope of the Santa Ynez Mountains between the Gaviota Pass to the west and the Santa Barbara/Ventura County line to the east. In total, these seven fires have burned over 100,000 acres, destroyed over 1,100 structures, and resulted in six fatalities. A map depicting areas that have been burned by recent wildfires is provided on page 30, and additional information about recent wildfires that have affected Santa Barbara is provided on page 31.

Conditions that contribute to a high wildfire hazard include the type, density and age of vegetation; weather conditions, such as high winds, low humidity and high heat; topography, such as steep slopes; access and roadway conditions; water supply; and response time required by Fire Department personnel and equipment. Other natural- and development-related conditions can also combine to influence the potential for and the severity of wildland fires. The Santa Barbara Fire Department's *Wildland Fire Plan* (2004) identified four high fire hazard zones in the City. The locations of the four fire hazard zones are depicted on Figure 20, High Fire Hazard Zones, of the *Safety Element Technical Background Report* (Appendix A) and are briefly described below.



Source: Santa Barbara General Plan Update Program EIR, 2010

City of Santa Barbara
General Plan
Santa Barbara Region Recent Wildfires

RECENT WILDFIRES IN SANTA BARBARA

The Jesusita Fire of 2009 burned the foothills north of and in the City of Santa Barbara.
(photo source: samedwardsfamily.com)

The 2008 Tea Fire started in Montecito on November 13 at 6:30 pm and was not controlled until November 17. Driven by sundowner winds gusting up to 70 miles an hour, the fire burned 1,940 acres and destroyed 210 homes. 106 of the burned homes were located in the City of Santa Barbara. A total of 2,235 firefighters and nine helicopters were used to fight the fire. Total suppression costs were estimated to be 5.7 million dollars.

Flames of the Jesusita Fire as seen from the waterfront area. Stearns Wharf is visible in the foreground.
(photo source: samedwardsfamily.com)

The 2009 Jesusita Fire started on May 5, 2009 in an area near Cathedral Peak and burned a total of 8,733 acres and 80 homes. Evacuation orders for affected areas were not lifted until May 13th. In total, 1,857 fire fighters, 111 fire engines, four helicopters and an air attack tanker were used to control the fire. Fire suppression costs were estimated to be 20 million dollars.

Flames from the 2008 Tea Fire are seen from De la Guerra Plaza adjacent to City Hall.
(photo source:a11news.com)

Strong winds blow smoke from the Jesusita Fire across the Santa Barbara Channel.
(photo source: earthobservatory.nasa.gov)

Extreme Foothill Zone

This zone has a combination of heavy vegetation located within the City and in the adjacent Los Padres National Forest, and slopes with a gradient greater than 30 percent. The majority of this zone is outside the Department's four-minute response time, and there are areas within the zone that have limited water supplies for fighting structure fires. The main roads in this zone meet Fire Department access standards; however, many smaller roads, driveways and bridges do not meet current standards. Portions of the Extreme Foothill Zone have been burned during recent fires, including the Coyote (1964), Sycamore Canyon (1977), Painted Cave (1990), Tea (2008) and Jesusita (2009) fires.

Foothill Zone

Vegetation in this zone includes a mix of heavy brush and canopy fuels provided by oak and eucalyptus trees; heavy vegetation in creek areas; and slopes with gradients that vary between 20 and 40 percent. The majority of this zone is within the Fire Department's four-minute response area; however, some of the main roads and many of the smaller residential roads do not meet the Department's road standards. This zone generally has adequate water supplies for fighting structure fires, which reduces potential fire hazards; however, the high density of residential structures located throughout this zone increases the wildfire hazard. The Foothill Zone has been affected by several wildfires, including the Coyote (1964), Sycamore Canyon (1977), Tea (2008) and Jesusita (2009) fires.

Coastal Zone

This zone has diverse pockets of vegetation, such as chaparral, oak forests, coastal sage scrub, landscape vegetation, agricultural lands and eucalyptus groves, and much of the vegetation occurs on slopes that range in gradient from 10 to 35 percent. The ocean's influence dominates weather patterns in this zone for most of the year; however, down canyon winds may occur that can cause the rapid spread of flames. The western portion of this zone is located beyond the Fire Department's four-minute response time standard. The majority of the roads in this zone meet the Fire Department's standards and water supplies also meet Fire Department requirements for fighting structure fires.

Coastal Interior Zone

The Coastal Interior high fire hazard zone has areas with moderate brush and heavy canopy fuels that are interspersed among areas with high concentrations of structures. The ocean's influence dominates weather patterns most of the year; however, down canyon winds can cause the rapid spread of flames on slopes that vary in gradient between 10 and 35 percent. This zone is within the Fire Department's four-minute response time standard, and the majority of the roads meet Fire Department's standards. This zone also meets the Fire Department's water supply standards.

Numerous regulatory requirements and risk reduction programs to minimize the effects of wildfires have been implemented by the City, as well as state and federal agencies. In general, these requirements include standards related to fire prevention and suppression, and making structures more resistant to wildfires. Some of the wildfire hazard reduction measures implemented by the City of Santa Barbra Fire Department include the provisions of the *Wildland Fire Plan;* California Building Code and Municipal Code requirements; vegetation management programs to reduce the amount of combustible vegetation in wildland and urban areas; and defensible space standards that minimize the amount of vegetative fuel around a building or structure, which increases its probability of surviving a wildfire. A defensible space perimeter will also provide firefighters with a safer working environment as a fire approaches.

The Fire Department generally conducts very little vegetation management in creek areas located in high fire hazard zones; however, vegetation management activities are occasionally deemed necessary to minimize hazards along roads, bridges or key defensible spaces to be used for fire fighting. Before vegetation management activities are conducted in or near creek areas, the Fire Department prepares a vegetation management plan, and measures to protect aquatic and riparian resources in the work area are identified and implemented. When required, the Department will obtain a Streambed Alteration Agreement (Fish and Game Code 1601) from the California Department of Fish and Wildlife prior to the implementation of the vegetation management work.

It is anticipated that future effects of climate change will include decreased precipitation, increased temperature, longer and more frequent periods of drought, and periodic high rainfall events that could result in an increase in the growth of grasses and other highly combustible vegetative fuels. These conditions would have the potential to result in an increase in the frequency and severity of wildfires in the Santa Barbara area. An increased risk for wildfires will place additional importance on the use of fire resistant construction techniques and the implementation of vegetation management programs, particularly in wildland-urban interface areas.

The City has implemented a variety of programs and procedures to assist property owners that have been affected by recent wildfires. Information and assistance can be obtained regarding a variety of fire-related reconstruction requirements, including debris removal; erosion control; development requirements for non-conforming buildings; requirements for soils reports; review and construction requirements for main and accessory structures; and the temporary use of residential trailers during construction. As part of the rebuilding effort, the City encourages homeowners to incorporate fire prevention, energy efficiency and sustainability measures into proposed residence designs.

STRUCTURE FIRES

The City of Santa Barbara Fire Department provides fire prevention, suppression and other emergency response services. In addition to responding to structure fires, the Fire Department responds to medical emergencies, accidents, hazardous material releases and rescues. The Fire Department also responds to aircraft emergencies at the Santa Barbara Airport. Non-emergency services provided by the Fire Department include conducting fire and life safety inspections, building inspections, fire code investigations, code compliance, development review and public education.

The Santa Barbara Fire Department operates seven fire stations and an aircraft fire fighting station at the Airport. In 2012, the Department had 89 firefighters to serve a resident population of approximately 90,000 people. This results in a fire fighter to resident ratio of almost one fire fighter per 1,000 residents, which is a good service ratio. The Fire Department estimates that during the day when visitors and out-of-town employees are present, the City's population increases to an average of approximately 123,000 people, which decreases the fire fighter to population served ratio.

Flooding Hazards

This section of the Safety Element provides a description of the three types of flooding hazards that have the potential to affect Santa Barbara: stream flooding that occurs when stormwater runoff overtops a creek's banks; coastal area flooding caused by ocean tides, sea level conditions and/or storm-generated waves; and the inundation of areas due to the failure of a dam. More detailed information regarding flooding-related hazards and their effects on the City is provided by the *Safety Element Technical Background Report* (Appendix A).

STREAM FLOODING

Stream flooding occurs when stormwater runoff in a stream channel exceeds the water carrying capacity of the channel, causing water to flow over the stream's banks. Stream channels located in the Santa Barbara area and their associated watersheds often experience short-duration, high-intensity rainfall events, which can result in high runoff rates and creek flows that rise quickly. Many of the natural creek channels in the City do not have the capacity to convey a sudden increase in flood flows that can occur during a large storm, and the areas with the greatest potential to experience out of channel flows are the lower creek reaches where streambed gradients flatten and channel bank tops are relatively low.

The magnitude and severity of flood events may be increased by a variety of natural- and development-related conditions. Natural factors can include the excessive growth of brush and trees within drainage channels, which may obstruct stream flows and result in an increase in floodwater heights. Fires within the watershed will result in the removal of vegetation that helps to control the amount and rate of stormwater runoff. Urban development often results in an increase in impervious surface areas, which changes the drainage area's stormwater runoff characteristics. These effects are referred to as "hydromodification" and can result in increased stormwater runoff volume, velocity, temperature, discharge duration, as well as an increase in erosion, sedimentation and other pollutants. The combined effect of more runoff reaching the stream channel in a reduced period of time can substantially increase flooding-related hazards and result in more severe and frequent floods.

Floods are generally described in term of their frequency of occurrence. For example, a 100-year flood is defined by evaluating the long-term average time period between floods of a certain size, and identifying the size of flood that has a one percent chance of occurring during any given year. A recurrence interval such as a 25-year or 100-year flood represents only the long-term statistical average time period between floods of a specific size. Floods of any size may occur at much shorter intervals or even within the same year.

To protect urban development from the impacts of flooding, stream channels are often "channelized" (i.e., straightened and/or lined with concrete or other material) to move water through the channel more efficiently. However, as runoff water emerges from the channelized section of the stream, it is often delivered to an unchannelized down-stream section at velocities that the natural section of the stream is not capable of adequately carrying. This can result in increased flooding impacts downstream and erosion of the stream bed and banks.

Four major watersheds drain through the City of Santa Barbara to the Pacific Ocean. The creeks that drain those watersheds include Arroyo Burro Creek, Mission Creek, Sycamore Creek and the Laguna Channel. The Arroyo Burro, Mission and Sycamore Creeks originate in the Santa Ynez Mountains and drain areas within the Los Padres National Forest as well as developed areas of the City. The Laguna Channel watershed drains an almost entirely urbanized watershed within the City. The Santa Barbara Municipal Airport is located on low-lying ground within the historic boundaries of the Goleta Slough, and is also in an area where four major creeks are located: San Pedro, Tecolotito, Carneros and Las Vegas Creeks.

The Federal Emergency Management Agency (FEMA) has designated flood hazard zones throughout the City, and areas subject to inundation during a 100-year storm are depicted on Flood Insurance Rate Maps. The boundaries of designated flood hazard areas may be updated by FEMA from time to time to reflect changed conditions within the watershed or to provide more accurate information about areas that may be subject to flooding. The designated 100-year flood zone areas in the City are generally depicted on Figure 24, 100-Year Flood Plain, of the *Safety Element Technical Background Report* (Appendix A) and are briefly described below. The location of individual neighborhoods that may be affected by flooding are described by the Land Use Element.

Arroyo Burro Creek

Floodwater from Arroyo Burro Creek during a 100-year storm may inundate an area north of and adjacent to U.S. 101 in the southeastern portion of the Upper State neighborhood. On the south side of the highway, areas of the Hidden Valley neighborhood may also be flooded. Small areas in the San Roque and Hitchcock neighborhoods adjacent to San Roque Creek, a tributary to Arroyo Burro Creek, may also experience flooding-related impacts.

Mission Creek

Flood zones along the northern portions of Mission Creek are generally confined to the creek channel until the creek enters the Oak Park neighborhood, where 100-year flood zones have been designated along the western portion and in the southeastern area of the neighborhood. Along the lower reaches of the creek, flooding may affect areas located in the West Downtown, Lower State, West Beach and Waterfront neighborhoods. Floodwater from Mission Creek can also enter the Laguna Channel watershed, which adversely affects the ability of the Laguna Channel to convey flood flows.

Sycamore Creek

Runoff from a 100-year storm is generally contained within or adjacent to the Sycamore Creek channel until it reaches the Eastside neighborhood, where the southern portion of the neighborhood may experience flooding. Sycamore Creek can also cause flooding impacts in portions of the East Beach neighborhood, where overbank flows occur due to a reduction in the creek channel slope and the resulting reduction in channel conveyance capacity.

Laguna Channel

Flooding associated with the Laguna Channel during a 100-year storm can affect portions of the Lower State and Milpas neighborhoods, the western end of the East Beach neighborhood, and extensive areas of the Waterfront and Lower East neighborhoods.

Airport Area

Extensive areas located at and adjacent to the Airport may be inundated during a 100-year storm. The new terminal building was constructed in accordance with the requirements of the City's Floodplain Ordinance, which required the structure to be elevated to the 100-year flood water elevation.

Flooding can be increased in low-lying areas located near the areas where creek or drainage channels discharge to the ocean when high tides coincide with intense rainfall events. The higher sea level conditions caused by high tides can slow the flow of water before it reaches the ocean, causing flood flows to back up into flood-prone areas located near the coast.

Numerous regulatory requirements and risk reduction programs have been implemented by federal, state and local agencies to minimize the effects of stream flooding. In general, these requirements include programs that reduce the potential for damage to structures and to provide and maintain flood control facilities. Some of the measures that reduce the risk and consequences of flooding in the City include the National Flood Insurance Program; the construction, operation and maintenance of flood control and drainage infrastructure by the Santa Barbara County Flood Control District and the City Public Works Department; and the City's Flood Plain Management Ordinance (Municipal Code Chapter 22.24) and Development Along Creeks Ordinance (Municipal Code Chapter 28.87).

Although the effects of climate change may result in overall drier conditions and a decrease in average amounts of precipitation, it is expected that the number of intense rainfall events will increase. If large storms occur more frequently, a corresponding increase in the frequency and severity of stream flooding is likely to occur and more extensive areas could be affected by flooding. In addition to an increase in storm intensity and frequency, flooding in coastal areas where streams meet the coast may be increased due to a rise in sea level. Accelerated sea level rise in California due to climate change is forecasted to be in the range of five to eight inches by the year 2030, 10-12 inches by 2050, and 31-69 inches by 2100.

DAM FAILURE

Dam inundation is the flooding of lands due to the release of impounded water resulting from the failure or overtopping of a dam. Dams can fail for one or a combination of reasons, including: overtopping caused by floods that exceed the capacity of the dam; failure of materials used in construction of the dam; movement and/or failure of the foundation supporting the dam; inadequate maintenance; or deliberate acts of sabotage.

The Lauro Dam and Reservoir is located north of and adjacent to the City limits and would have the potential to result in inundation impacts to the City should a failure of the dam occur. The dam was constructed in 1952 by the Bureau of Reclamation as part of the Cachuma Project, and is operated by the Cachuma Operations and Maintenance Board. The Bureau of Reclamation and other federal agencies, such as FEMA, have established extensive regulatory requirements and programs that require ongoing inspection and maintenance of federally-owned dams. In addition to these programs, seismic strengthening modifications to the dam were completed in 2007. With the continued implementation of existing programs, the risk of a catastrophic dam failure of the Lauro Dam and resulting effects in the City is very low.

COASTAL FLOODING AND INUNDATION

Coastal flooding refers to a temporary covering of areas on or near the coastline caused by stream flow, high tides, ocean storm conditions, or a combination of those processes. Coastal inundation refers to a permanent covering of an area by ocean water. Beach and adjacent low-lying areas would be the most susceptible to the effects of coastal inundation.

Coastal flooding in Santa Barbara has generally occurred as a result of large, storm-generated ocean waves moving onshore combined with high tide conditions. Figure 25, Coastal Storm Surge Hazard Areas, of the *Safety Element Technical Background Report* (Appendix A) depicts areas of the City that could be flooded as a result of storm surge during a 100-year storm under existing sea level conditions. Coastal areas that would be expected to incur temporary flooding-related damage include most beaches and adjacent areas as far inland as Shoreline Drive and Cabrillo Boulevard.

Figure 25 also depicts areas that could be affected by coastal flooding caused by a 100-year storm plus the effects of a 55-inch increase in sea level. Such an increase in sea level is near the high end of sea level rise projections for conditions that could exist by the year 2100. Under such possible future conditions, the areas that could be affected by coastal flooding are located substantially further inland than under existing sea level conditions, and include much of the East Beach, Lower East and Laguna neighborhoods. Future coastal flooding conditions at the Airport would also be expected to increase in terms of frequency and severity, with additional low-lying areas near the airport experiencing the effects of coastal flooding during large storms.

There is a level of uncertainty associated with predicting how sea level rise conditions will affect coastal and inland areas because it is not known how fast or how much sea level conditions will continue to change in the future. However, it is reasonable to expect that as sea level increases, impacts resulting from coastal flooding will also increase.

The potential for City beaches and adjacent areas to be inundated as a result of a climate change-related increase in sea level will be controlled by factors such as the future rate and magnitude of sea level rise, and the width and elevation of the City's beaches. Projections regarding the possible magnitude of sea level rise vary substantially; however, the *City of Santa Barbara Sea Level Rise Vulnerability Study* concluded that over an intermediate time frame (to 2050) a projected 14-inch rise in sea level would have a low probability of resulting in a permanent loss of City beaches. If sea levels were to continue to rise, areas that would have formerly only been temporarily flooded or submerged during very high tides and/or large El Niño storms would gradually begin to be inundated permanently. Over a long-term period (to 2100), a 55-inch rise in sea level would substantially increase the probability of permanent beach and adjacent area inundation.

Hazardous Materials

The benefits derived from the use of chemicals are substantial but due to their widespread use, occasional accidental releases to the environment occur. In addition to hazardous materials used by commercial, industrial and institutional uses, hazardous materials such as cleaners, paint, automotive and garden products, hobby supplies, and swimming pool chemicals are used in substantial quantities in residential areas. The improper use or disposal of these types of hazardous materials can have adverse health, safety and environmental consequences. An emerging health and safety issue is the improper disposal of pharmaceuticals, which when introduced into the environment can affect human health and ecosystems.

The Santa Barbara County Fire Department's Site Mitigation Unit and Leaking Underground Fuel Tank programs provide regulatory oversight for the assessment and remediation of hazardous material release sites within the City of Santa Barbara. Several state agencies also provide remediation oversight and information that identifies sites with soil and groundwater contamination, including the California Environmental Protection Agency, Department of Toxic Substances Control, and the California State Water Resources Control Board.

The areas of the City with the highest concentration of contaminated sites are generally located in the commercial and industrial areas of the Downtown, Eastside and Waterfront/Harbor areas; in the vicinity of Cottage Hospital; along Cliff Drive in the Mesa area; along Upper State Street; and at and near the Airport. The areas of the City where hazardous material release sites are most commonly located are depicted on Figure 26, Hazardous Material Release Areas, of the *Safety Element Technical Background Report* (Appendix A).

One of the regulatory programs commonly used to minimize risk from hazardous materials is the requirement for businesses that use hazardous material in excess of specified quantities to prepare a Hazardous Material Business Plan. Business Plans provide information that may be used by first responders to prevent or mitigate impacts to public health and safety and the environment resulting from a release or threatened release of a hazardous material. Business Plans are also used to satisfy federal and state Community Right-To-Know laws that require disclosure of hazardous material use characteristics to the public.

Public Safety

Public safety issues addressed by this Safety Element include risk from aircraft operations at the Santa Barbara Municipal Airport; the transport of hazardous materials along local highways and rail lines through the City; the presence of natural gas transmission and distribution pipelines; and the creation of electromagnetic fields by high voltage transmission lines. More detailed information regarding these hazards and their effects on the City is provided in the *Safety Element Technical Background Report* (Appendix A).

AIRCRAFT OPERATIONS

To assist in the evaluation of land use compatibility issues involving airports, in 1967 the California Legislature authorized the formation of Airport Land Use Commissions and the preparation of Airport Compatibility Land Use Plans. It is the objective of these planning programs to minimize the public's exposure to safety hazards while providing for the orderly expansion of airports where needed. An *Airport Land Use Plan* for the public airports in Santa Barbara County was adopted in 1993 and is administered by the Santa Barbara County Association of Governments (SBCAG). SBCAG and the Santa Barbara Airport Department update the *Airport Land Use Plan* periodically.

The type and intensity of future development that may occur on City property at and adjacent to the Airport is controlled by several land use planning programs, including the requirements of the Airport Zoning Ordinance, Title 29 of the Municipal Code; the *Airport Industrial Area Specific Plan; City of Santa Barbara Coastal Plan for the Airport and Goleta Slough,* and the *Aviation Facilities Plan.* In addition, future land uses on Airport property would be required to comply with the standards established by the most-current version of the *Airport Land Use Plan,* as well as Federal Aviation Administration (FAA) and other applicable safety regulations.

The potential for future development on properties located in the vicinity of the Airport to result in land use or safety conflicts would be minimized by complying with existing FAA regulations and reviewing projects to ensure that they are consistent with the land use planning objectives of the most-current *Airport Land Use Plan* and the *California Airport Land Use Planning Handbook.*

HAZARDOUS MATERIAL TRANSPORT

U.S. 101 and the Union Pacific Railroad extend through Santa Barbara from east to west and both are used for the transportation of hazardous materials. The City has limited control over the volume and type of materials transported along these major transportation corridors and it can be expected that various types of hazardous materials, including explosives, compressed and liquefied gasses, petroleum products, agricultural chemicals, industrial chemicals, military ordnance, radioactive material and hazardous wastes will pass through the City on a regular basis. The potential for a spill or leak to occur while hazardous materials are being transported through the City is very low; however, the consequences of such an event have the potential to be high.

Another major transportation facility in the Santa Barbra area is SR 154; however, the transportation of hazardous waste is restricted along the portion of SR 154 that extends between its southern junction with U.S. 101 and the SR 246 intersection near Solvang. In addition, the California Assembly passed House Resolution HR 31 in 2012, which urges truck drivers traveling through Santa Barbara County to continue on State Highway Route 101 rather than using SR 154.

In the event of a transportation-related hazardous material release, emergency response is provided by the California Highway Patrol, City Fire Department and the Santa Barbara County Fire Department, along with Caltrans and local Sheriff and Police Departments to provide containment, enforcement and traffic routing assistance. If necessary, the California Emergency Management Agency (Cal EMA) Hazardous Materials Section will coordinate the implementation of a hazardous material emergency response, and provide state and local managers with emergency coordination and technical assistance.

NATURAL GAS PIPELINES

Risks to the public from natural gas pipelines result from the potential for an unintentional release, which can impact surrounding populations, property, and the environment. These consequences may result from fires or explosions caused by ignition of the released gas, as well as possible toxicity and asphyxiation effects. Pipeline releases can occur due to a variety of causes, including internal and external corrosion, excavation damage, mechanical failure, operator error, and natural force damage (e.g., earthquakes).

Although natural gas pipeline incidents are infrequent, such an event has the potential to result in significant consequences that may impact the general public. This was evidenced in 2010 in the City of San Bruno when a 30-inch natural gas transmission pipeline ruptured and the ensuing explosion and fire killed eight people, destroyed 37 homes, damaged 18 homes and resulted in numerous injuries.

In the Santa Barbara area, the Southern California Gas Company is the natural gas utility company and operates a system of natural gas transmission and distribution lines that are generally located in the northern portion of the City, along the waterfront and on airport property. The Gas Company implements a pipeline safety program that includes measures such as: odorizing gas so leaks are more easily detectable; conducting leak surveys and pipeline patrols to identify missing pipeline markers, indicators of pipeline leaks, and construction activity that could damage a pipeline; interior and exterior pipeline corrosion control measures; and inspection and maintenance of valves, underground vaults, pipeline crossings, and pressure-relief devices. Pipeline safety programs are also implemented by various state and federal agencies.

ELECTROMAGNETIC FIELDS

Electric and magnetic fields are created by high voltage electricity transmission lines, distribution lines that bring electricity into structures, wiring within households, and by common household appliances that use electricity. The strength of electric and magnetic fields produced by electrical lines and appliances diminishes quickly as the distance from the source of the field increases.

Since the mid-1970's a variety of scientific studies have demonstrated that biological changes can be produced by electric and magnetic fields. More recent scientific research has focused on exposure to electromagnetic fields (EMF) rather than electric fields. Although some studies raised the possibility of emotional, behavioral, and reproduction effects, public concern regarding EMF exposure has focused primarily on a statistical association between magnetic fields and cancer. Although the results of studies regarding this issue vary, most have concluded that there is insufficient data to conclude that there is a cause and effect relationship between EMF and cancer.

Southern California Edison (SCE) provides electrical service to the City. The transmission system in the City includes several large tower-mounted 66 kilovolt (kV) lines extending east to west along the base of the Santa Ynez Mountains, approximately two miles north of the City. The electrical distribution system operates at 2.4 kV, 4.16 kV and 16.5 kV and is distributed as needed throughout the City. Approximately 30 percent of the City's distribution system is underground.

There are no federal or California numerical thresholds for exposure to electromagnetic fields. In 2006, the California Public Utility Commission determined that it is appropriate for utilities to continue to take no-cost or low-cost measures where feasible to reduce EMF exposure from new or upgraded utilities (CPUC Decision D.06-01-042). These types of actions may include design changes to utility systems; routing lines to limit exposures to areas of concentrated population and group facilities such as schools and hospitals; installing taller distribution line support structures; widening right of way corridors; and the burial of distribution lines.

On a local level, it has been the City of Santa Barbara's policy to limit EMF exposure in land use decisions as feasible to do so. Reducing EMF exposure may be achieved by implementing a practice referred to as "prudent avoidance," which is a principle of risk management indicating that reasonable efforts to minimize potential risk should be taken when the actual magnitude of the risk is unknown.

When electromagnetic energy moves through electrical wires, the movement results in the generation of electric and magnetic fields. When electromagnetic energy moves from one point to another by waves propagated through space, the movement is accompanied by the formation of radiowaves (or radio frequency radiation). The potential for exposure to radio waves is commonly a concern associated with the installation and operation of telecommunication facilities. The 1996 Telecommunications Act is administered by the Federal Communications Commission and established standards regarding the construction, modification and placement of facilities such as towers for telecommunication systems. The Act established limits for occupational and general population exposure to radio frequency radiation, and also preempts state and local government regulation of telecommunication facilities on the basis of environmental effects of radio frequency emissions.

Public Services

The City of Santa Barbara provides a wide variety of services to protect and enhance the health, safety and general well-being of the City's residents. Public services provided by the City include widely-used infrastructure systems such as potable water production, treatment and distribution; wastewater collection and treatment; road construction and maintenance; solid waste collection, recycling and disposal services; and the operation and maintenance of the City's airport and harbor. Other public services provided by the City include public safety functions such as police and fire protection, and parks and recreation facilities and functions.

Public services provided by the City, such as fire and police protection services, are essential to reduce risk and manage events associated with safety-related hazards. The effective delivery of emergency response efforts in the aftermath of a disaster or accident is influenced by the ability of local emergency response organizations and infrastructure systems to operate at or near planned capabilities. Providing improvements to the City's critical emergency response infrastructure, such as upgrades to fire stations or the replacement of the aging Police Department building receives ongoing attention as part of the City's annual budget and capital improvement processes. A review of unfunded capital improvement projects was conducted by the City and culminated in a report titled *Keeping Santa Barbara in Shape, Infrastructure Financing Report for the City of Santa Barbara (2008).* In addition to identifying various public service and emergency response infrastructure deficiencies, the report identified financing mechanisms that may provide funding to implement needed infrastructure improvements. The Santa Barbara Annex to the *Multi-Jurisdictional Hazard Mitigation Plan* also includes recommended actions to reduce risks to City-owned infrastructure that may result from geologic, fire and flooding hazards to increase the likelihood that critical services and facilities will remain functional after a disaster. The actions recommended by the Santa Barbara Annex are reviewed and revised at least every five years to reflect updated hazard reduction priorities and funding constraints.

Other public service infrastructure systems and programs facilitate emergency response capabilities, such as providing adequate long-term water supplies and maintaining reliable water delivery systems. As indicated by the City's *Climate Action Plan* (2012), maintaining adequate water supplies could become a priority if future weather changes result in less water storage and water availability in California due to decreased average rainfall, more droughts, less precipitation as snow, and earlier melting of snow pack. Warmer weather would also increase demand for irrigation of agriculture and landscaping. Providing and maintaining safe road systems is also an essential component of the City's ability to provide emergency response services and to facilitate evacuations during emergency events.

A vital public service function conducted by the City is a comprehensive program of emergency preparedness. Pre-emergency planning conducted by the City is coordinated with a multitude of Federal and State agencies and regulations, Santa Barbara County and other nearby counties, and other nearby cities. The following information provides a brief overview of the emergency preparedness actions and planning programs that have been implemented by the City.

EMERGENCY PREPARDNESS

The purpose of emergency planning is to identify policies and actions that can be implemented over the long-term to reduce risk and the potential for future losses, to respond effectively to emergency or disaster conditions and minimize social disruption, and to aid in post-disaster recovery. There are many aspects to emergency planning; however, the basic concepts include developing plans and procedures, maintaining risk reduction and loss prevention programs, managing available resources to respond during an emergency, implementing mutual aid agreements, training people and educating the public.

Many local, regional, state-wide and federal emergency preparedness and response programs have been prepared to assist in emergency management and recovery.

City of Santa Barbara

Emergency Response Planning

One of the major elements of the City's emergency planning program is the **Emergency Operations Plan** (2007). The Emergency Operation Plan outlines response procedures that would be implemented after a natural disaster, technological incident, or security incident. The objective of the plan is to establish an effective organization capable of responding to emergency situations using all appropriate facilities and personnel in the City. The Emergency Operation Plan assigns tasks and specifies policies and procedures for the coordination of emergency staff and service elements, and identifies emergency response actions for large-scale emergencies. These measures are to be implemented in manner reflecting effective and economical allocation of resources for the maximum benefit and protection of the civilian population in time of emergency.

The Emergency Operation Plan was developed as part of the California Standardized Emergency Management System (SEMS) and the National Incident Management System (NIMS), and is an extension of the State Emergency Plan and the National Response Plan (NRP). SEMS has been adopted by the City to manage responses to multi-agency and multi-jurisdiction emergencies and to facilitate communication and coordination between responding agencies. Local governments must use SEMS to be eligible to recover costs under State's Disaster Assistance Programs. Following a presidential disaster declaration, NIMS and the Hazard Mitigation Grant Program are activated. The purpose of these programs is to fund projects that are cost-effective and substantially reduce the risk of future damage, hardship, loss, or suffering from a major natural disaster.

The Emergency Operations Plan outlines the responsibilities of the various City government departments during emergency situations. The Fire Department's role includes direct response to fires, medical emergencies, environmental emergencies, and natural disasters. Fire Department responses may also be coordinated with mutual aid agreements with other local, state and federal agencies. The Department's Office of Emergency Services coordinates the City's response to disasters, educates residents regarding disaster preparedness, and operates the City's Emergency Operations Center. The Emergency Operations Center is activated when field response agencies need support during any significant incident. The Office of Emergency Services also coordinates emergency service functions of the City with other public agencies and affected citizens, corporations and organizations. In many emergency situations, Police Department officers are among the first responders and implement traffic control and evacuations. The Public Works Department participates in a wide variety of activities, including: recovery operations; coordinating with public utility companies; providing transportation for emergency agencies of the City; assuring that an adequate supply of water is available for emergency requirements, that an adequate supply of potable water is available, and that adequate sanitary facilities are provided; and assisting in and providing for traffic controls and warning signs. In the event of a natural disaster, the Waterfront Department, Community Development and Building Divisions, Airport and Parks and Recreation Departments may also have emergency response duties.

The Emergency Operations Plan also outlines specific disaster response and recovery objectives. Short term recovery objectives include:

- Utility restoration
- Expanded social, medical, and mental health services
- Re-establishment of City government operations
- Clearing and repairing transportation routes
- Debris removal
- Cleanup operations
- Abatement and demolition of hazardous structures.

The major objectives of long-term recovery operations include:

- Coordinating delivery of social and health services
- Review of potential improvements in land use planning
- Re-establishing the local economy to pre-disaster levels
- Recovery of disaster response costs
- Effectively integrating mitigation strategies into recovery planning and operations.
- Improving the Santa Barbara Emergency Operations Plan

The City of Santa Barbara's **Emergency Services Organization** is managed by the Emergency Services Council and is comprised of all officers and employees of the City, together with those volunteer forces enrolled to aid the City during a disaster, and all groups, organizations and persons who may by agreement or operation of law be charged with duties related to the protection of life and property in the City during a disaster. These groups include, but are not limited to: school districts, the Santa Barbara Community College District, Santa Barbara Metropolitan Transit District, American Red Cross, and the Amateur Radio Emergency Services.

The City uses the Santa Barbara County Sheriff's **Reverse 911** system, which has the ability to alert the public regarding emergency events by sending recorded messages to local phone numbers. The system can be used to alert specific neighborhoods or the entire city about conditions such as evacuation warnings, flood and fire events, hazardous material spills, and missing persons. Landline phone numbers are on the Reverse 911 list even if the number is unlisted. Digital or internet telephone service must be "E911 Compliant" to receive Reverse 911 calls. Cell phone numbers must be added to the Sheriff's Reverse 911 database, which can be done through the Sheriff's Reverse 911 registration internet site.

Evacuation Planning

Another major component of the City's emergency response planning efforts pertains to evacuating areas in response to a fire, flood, tsunami warning or other similar incidents. Evacuation planning has been described as being "a process not a product"; however, the Fire Department has developed and maintains evacuation plans and procedures, particularly in regard to the evacuation of high fire hazard areas in the foothill areas of the City. Fire evacuation plans and procedures maintained by the Fire Department are described in the *Wildland Fire Plan* (2004) and are summarized below.

The identification of areas to be evacuated, the timing of voluntary evacuation warnings and mandatory evacuation orders, and the identification of evacuation routes is typically determined from information received from Fire Department units regarding fire behavior conditions and movement. Directing the evacuation of neighborhoods during a wildfire is primarily the responsibility of the Police Department and cooperating law enforcement agencies.

The Fire Department's evacuation plan separates the high fire hazard areas throughout the Santa Barbara front country (the Extreme Foothill Zone and Foothill Zone identified on Figure 20, High Fire Hazard Zones, of the *Safety Element Technical Background Report*) into "evacuation blocks." The boundaries of individual blocks were determined based on the topography of major canyons and the existing road system. Fire response and evacuation planning for each block considers and includes items such as traffic closure points, fire equipment response routes, fire resources that would respond to a fire based on first, second and third alarms, probable evacuation routes, incident command posts to facilitate management of the fire, fire staging areas for equipment and personnel, evacuation centers for civilians and animals, and other fire-related risks that may be unique to an individual block.

The road system within each evacuation block was evaluated to determine the best routes to use for fire response equipment and probable evacuation routes. Efforts were made to separate fire response routes and evacuation routes where possible; however, in many blocks this is not feasible. It must be emphasized that the identified response and evacuation routes identified by the *Wildland Fire Plan* may be modified at the time of the incident in response to fire conditions. Therefore, the identified roadways should only be considered as probable evacuation routes.

Evacuations are conducted to the extent possible by issuing warnings and orders to individual evacuation blocks based on location and characteristics of the fire. By phasing evacuation operations, the potential for severe roadway congestion can be minimized. Notifications to specific evacuation blocks can be disseminated in a variety of ways, including Reverse 911 calls, radio and television announcements, social media, emergency response equipment public address systems, and door to door notifications.

The Fire Department continues to study and plan for evacuation events. Future updates to existing evacuation procedures will consider factors such as studies of how the public can be expected to respond to emergency conditions, and lessons learned from evacuations conducted in response to recent fires in Santa Barbara and other locations.

Santa Barbara County

The Santa Barbara County **Office of Emergency Management** is responsible for emergency planning and coordination among the Santa Barbara Operational Area entities, which includes:

- Each of the incorporated cities in the County.
- Special districts, including the Air Pollution Control District; and fire, sanitary, school, vector control, and water districts.
- Volunteer Organizations, including the American Red Cross, Amateur Radio Emergency Services, Equine Evacuation, and Montecito Emergency Response & Recovery Action Group, and Volunteer Organizations Active in Disasters.

- Industry Groups such as, Community Awareness and Emergency Response, petroleum industry mutual aid group, and the Santa Barbara Industrial Association.

The Office of Emergency Management also coordinates with the emergency services offices of Ventura and San Luis Obispo Counties; prepares and maintains the *Santa Barbara County Operational Area Multi-hazard Functional Plan* and the *Santa Barbara County Multi-Jurisdictional Hazard Mitigation Plan*; maintains and operates the County Emergency Operations Center, coordinates disaster plans and exercises with the County's incorporated cities; assists County departments in developing department emergency plans, and provides public education.

The *Santa Barbara County Multi-Jurisdictional Hazard Mitigation Plan* addresses a variety of hazards that have the potential to affect Santa Barbara County and the City of Santa Barbara, and hazard-related issues specifically related to Santa Barbra are addressed in the Santa Barbara Annex to the Plan. Overall, the analysis and risk reduction programs and recommendations included in the Plan are provided to achieve three hazard reduction goals:

- Promote disaster-resistant future development.
- Build and support capacity and commitment for existing assets, including people, critical facilities/infrastructure, and public facilities, to become less vulnerable to hazards.
- Enhance hazard mitigation coordination and communication.

State of California

The **California Emergency Management Agency** (Cal EMA) is the primary emergency response and coordination agency for the State and was established as part of the Governor's Office in 2009 by Assembly Bill 38 (Nava), which merged the duties, powers, purposes, and responsibilities of the former Governor's Office of Emergency Services with those of the Governor's Office of Homeland Security.

Cal EMA is responsible for the coordination of state agency response to major disasters and support of local government. The Agency is responsible for assuring the State's readiness to respond to and recover from all hazards, including natural, manmade, and war-caused emergencies and disasters, and for assisting local governments in their emergency preparedness, response, recovery, and hazard mitigation efforts. During major emergencies, Cal EMA will coordinate region-wide and mutual aide responses to emergencies; provide equipment and support to local agencies; and provide search and rescue support. Cal EMA also maintains a 24-hour hazardous material release hotline, and relays spill reports to other state and federal response and regulatory agencies. Cal EMA serves as the "grantee" for federal disaster assistance, principally from the Federal Emergency Management Agency (FEMA), and helps local governments assess damages and assists them with federal and state grant and loan applications.

Federal Emergency Management Agency (FEMA)

FEMA's mission is to "support our citizens and first responders to ensure that as a nation we work together to build, sustain, and improve our capability to prepare for, protect against, respond to, recover from, and mitigate all hazards." FEMA has many roles; however, a primary responsibility is to coordinate the response to a disaster that has occurred in the United States and that overwhelms the resources of local and state authorities. The Governor of the state in which the disaster occurs must declare a state of emergency and formally request from the President that FEMA and the federal government respond to the disaster. FEMA provides a wide variety of services, including disaster response preparation, disaster survivor assistance, and disaster response and recovery operations.

Goals, Policies and Implementation

A top priority for the City is to prepare for hazard events that cannot be avoided, such as earthquakes, fires and floods; and to facilitate the recovery of the community after a disaster occurs. The combined benefits of minimizing hazard-related risk and pre-disaster planning supports the general safety and well-being of the community, and promotes community resiliency by reducing the effects of hazards in terms of injury and loss of life, property damage, and loss of natural and economic resources.

An important function of the City's development review process is to identify and evaluate natural and human-caused hazards that may adversely affect a project or the community, and to reduce hazard-related risk by methods such as hazard avoidance, project design measures, compliance with regulations, and the implementation of mitigation measures. The Safety Element facilitates this important planning function by providing information that guides the evaluation of hazard-related effects; by providing policies that protect the community from hazard-related risk; and by supporting the implementation of programs intended to enable and expedite the recovery of the community after a disaster occurs.

The following goals, policies and possible implementation actions are intended to reduce the effects of natural and human-caused hazards that have the potential to affect Santa Barbara. The goals, policies and implementation actions have been developed during the preparation of Safety Element Update. Other policy development sources include the 2011 General Plan, the City's Climate Action Plan, the City's Local Coastal Program, and the original 1979 Seismic Safety/Safety Element.

GOALS

- ***Community Resilience:*** Promote community resilience through risk reduction, public education and emergency response planning and programs.
- ***Development Review:*** Use the development review process to minimize public and private risk caused by natural and man-made hazards.
- ***Present and Future Service Needs:*** Ensure that public infrastructure and services are planned, sited, upgraded and maintained to meet present and future service needs efficiently, economically and in a manner consistent with a sustainable community and climate change.

Emergency Response Planning

S1. **Emergency Response Planning.** Work cooperatively with federal, state, county and other local jurisdictions to promote a high level of readiness to respond to emergencies, update emergency response plans as needed, and to avoid and reduce the effects of disasters and emergencies on the City and its residents.

S2. **Emergency Workforce.** Work cooperatively with other jurisdictions in the South Coast Region to ensure that essential workers are available and ready to respond adequately and with timeliness in the event of a disaster.

Possible Implementation Actions to be Considered

S2.1 City Disaster Service Workers. Encourage city employees to have personal and family disaster plans and understand their role and responsibility as a disaster service worker.

S2.2 Public Education. Promote public education on emergency and disaster preparedness to enhance individual and overall community resilience.

S3. **Consideration of People with Disabilities in Emergency Planning.** Update evacuation plans and other emergency or contingency plans with provisions addressing the safety of people with special needs and disabilities.

S4. **Incorporate Adaptation in Development.** As applicable, private development and public facilities and services may be required to incorporate measures to adapt to climate change.

Possible Implementation Actions to be Considered

S4.1 Climate Change Adaptation. New public and private development or substantial redevelopment or reuse projects shall estimate the useful life of proposed structures, and, in conjunction with available information about established hazard potential attributable to climate change, incorporate adaptation measures in the design, siting, and location of the structures.

S4.2. Adaptation Guidelines. The City shall prepare adaptation guidelines for development projects, and to the extent of information available to the City, provide information about potential climate change hazards to developers.

S5. **Community Resilience Planning.** Participate in community resiliency planning processes to help improve initial local response/relief efforts, subsequent recovery phases of emergencies, and ongoing community self-sufficiency and sustainability.

Possible Implementation Actions to be Considered

S5.1 Plan products. Develop the following as part of resiliency planning efforts:

a. Data base of maps and inventories of relief facilities, resources, businesses, and people that can help provide community relief during emergencies; the means for informing the public of resources data base; and a process for maintaining and updating data base information.

b. An outline and example for development of neighborhood plans.

c. An outline of additional community actions or projects for improvement to facilities, equipment, supplies, etc. that would benefit community resiliency (e.g., communications systems improvements).

S5.2 Plan process. Conduct the resilience planning process as a broad, cross-sector effort in coordination with the South Coast to engage public and institutional involvement, including:

- Public safety agencies
- Neighborhood groups
- Businesses, non-profit groups, and other non-governmental entities
- Health care facilities and practitioners (e.g., hospital, clinics)
- Relief supplies and volunteers (e.g., Red Cross, DRI)
- Hotels and Institutional facilities (e.g., schools; churches, Fairgrounds)
- Water, wastewater, waste management agencies/companies (including debris removal)
- Local agriculture, groceries, and restaurants
- Energy utilities and companies
- Transportation companies and agencies
- Communications companies
- Animal care facilities; funeral facilities; and other special needs facilities
- Local government departments and special districts (information systems; building & safety; animal control, vector control; etc.).

Development Review

S6. **Hazard Reduction.** Measures to reduce the effects of hazards to an acceptable level of risk shall be identified and evaluated during the development review process. The types of measures to be considered and implemented include:

a. Hazard avoidance

b. Project design measures

c. Compliance with regulations

d. Implementation of mitigation measures

Possible Implementation Actions to be Considered

S6.1 Information Resources. Maps depicting areas that have been or may be affected by natural and human-caused hazards should be maintained by the City. These maps may be updated from time to time when new information regarding the location or severity of hazards becomes available.

S6.2 Risk Evaluation. Proposals for new development may be required to provide an evaluation of how natural and human-caused hazards may adversely affect the project, and to identify feasible measures to reduce hazard-related risk to an acceptable level. Required hazard evaluation reports are to be prepared and signed by a qualified individual acceptable to the City. At its discretion, the City may require peer review of submitted reports.

Geologic and Seismic Hazards

S7. **Fault Rupture.** Avoid placing new structures for human occupancy across or adjacent to active or potentially active faults.

S8. **Ground Shaking.** Reduce the effects of earthquake ground shaking through appropriate building design requirements for new buildings and retrofit measures for existing buildings.

S9. **Liquefaction.** Foundation preparation recommendations identified by project-specific soils investigations shall be included in proposed building plans.

S10. **Slope Failure.** Discourage new development in areas where substantial slope movement has occurred in recent or historic times. Encourage development in areas designated as having a high or moderate slope failure risk to incorporate design and construction techniques that minimize slope failure risk to the extent feasible.

S11. **Soil Erosion.** Implement Best Management Practices to control the effects of erosion and sedimentation.

S12. **Expansive Soil.** Implement appropriate site preparation and structural design measures to minimize the effects of expansive soils.

S13. **Radon.** Encourage new or remodeled buildings intended for human occupancy located in areas that have a high potential for elevated radon concentrations to incorporate appropriate control measures into the design of buildings.

S14. **Geologic and Seismic Hazard Risk Reduction.** Development projects shall implement design and mitigation measures to reduce the risk of damage or loss due to geological and seismic hazards to an acceptable level.

Possible Implementation Actions to be Considered

S14.1 Hazard Evaluations. Hazard evaluations may be required consistent with the recommendations of the Geology and Geohazards Master Environmental Assessment, Technical Report and Evaluation Guidelines.

S14.2 Fault Setbacks. Structures for human occupancy should typically be setback 50 feet from the location of a fault. This setback distance may be increased or decreased based on the recommendations of the site-specific fault evaluation that was conducted to determine the location of the fault.

S14.3 Utilities that Cross Faults. For linear utility infrastructure (e.g., water, sewer, gas pipelines) that must cross the location of a known fault, appropriate safety measures shall be provided.

S14.4 Building Code Updates. The City will minimize ground shaking-related hazards to structures by continuing to review, amend and adopt updated provisions of the California Building Code to incorporate and implement building design requirements.

S14.5 Unreinforced Masonry Buildings. Implement existing building retrofit programs that address structural deficiencies in existing buildings that have the potential to result in significant safety hazards during earthquakes.

S14.6 Seismic Strengthening. Promote and implement a prescriptive seismic strengthening program to reduce the potential for damage to existing structures that do not meet current building code requirements.

S14.7 Minimize the Effects of Soil Erosion. Minimize soil erosion at construction sites by implementing Best Management Practices, such as those identified by the City's Storm Water Management Program.

S14.8 Minimize the Effects of Expansive Soil. Minimize the effects of expansive soil through site modifications and/or building designs.

S15. **Tsunami.** New development in areas designated as a tsunami hazard zone shall be designed to minimize the potential for tsunami-related damage to the extent possible.

Possible Implementation Actions to be Considered

S15.1 New Building Design. New buildings located in the designated tsunami hazard zone should be designed to resist collapse and minimize the risk of death, injury or property damage should a tsunami occur.

S15.2 Minimize Open Storage Areas. Land uses within designated tsunami hazard areas that require extensive areas of open storage should be discouraged to reduce the amount of debris that may be generated by a tsunami.

S15.3 Minimize Structural Damage. To the extent feasible, divert water to acceptable locations using structures such as walls, compacted terraces and berms, and parking structures.

S16. **Seiche.** Potential seiche hazards shall be considered during the design and environmental review of new development located adjacent to the Harbor and the Lauro Reservoir.

Possible Implementation Actions to be Considered

S16.1 Appropriate Structure Setbacks. New development located at the Harbor and adjacent to the Lauro Reservoir should, to the extent feasible, provide appropriate setbacks that minimize the potential for inundation from seiche waves.

S17. **High Groundwater.** Development in areas with known high groundwater conditions, or where historic high groundwater levels could return to previous high levels, shall be required to implement appropriate control measures and/or be designed to minimize high groundwater-related effects to the project.

Possible Implementation Actions to be Considered

S17.1 Minimize the Effects of High Groundwater. Proposed building projects located in areas with existing or historic high groundwater conditions should determine a "design groundwater elevation" based on a review of current and historic groundwater level data and provide measures to minimize the potential for adverse effects.

S18. **Sea Cliff Retreat.** Buildings intended for human occupancy shall be designed and located so that erosion of the sea cliff will not be substantially increased by the project; and the building will not be adversely affected by sea cliff retreat for a minimum period of 75 years, the typical useful life of a new building.

S19. **New Structure Design.** New bluff-top structures shall be located and designed to minimize adverse effects to the bluff (*e.g.,* a substantial increase in water percolation, weight placed near the bluff edge, or drainage over the bluff face).

Possible Implementation Actions to be Considered

S19.1 Structure Setback from the Bluff Edge. The required setback from the bluff edge shall be determined by an analysis that includes the most recent methodology used by the Coastal Commission. Modifications to the prescribed setback calculation methodology may be implemented pending concurrence by the City to reflect site-specific geological conditions.

California Coastal Commission Guidelines for determining the required setback from the bluff edge are provided in Appendix B of the Safety Element Technical Background Report.

S19.2 Bluff Top Drainage. All new development of bluff top land shall have drainage systems carrying run-off away from the bluff to the nearest public street. In areas where the landform makes landward conveyance impossible, and where additional fill or grading is inappropriate or cannot accomplish landward drainage, private bluff drainage systems may be permitted if:

a. They are sized to accommodate run-off from all similarly drained parcels bordering the subject parcel's property lines;

b. The owner of the subject property allows for the permanent drainage of those parcels through his/her property;

c. The drainage system is designed to be minimally visible on the bluff face.

d. The drainage system is designed and constructed to operate properly with only minimal maintenance requirements.

S20. **Sea Cliff Retreat.** All development, redevelopment, renovations and additions on bluff-top parcels shall consider the effects of sea cliff retreat over the life of the project. The potential effects of climate change on sea cliff retreat rates shall also be considered.

Possible Implementation Action to be Considered

S20.1 Sea Cliff Development Guidelines. The following guidelines shall be used for development on sea cliffs.

a. Bluff setbacks shall be adequate to address long-term erosion and slope stability issues.

b. New development on top of a cliff shall be placed at a distance away from the edge of the cliff, such that potential accelerated rates of erosion and cliff material loss associated with climate change-induced sea level rise, or an area- or site-specific geologic investigation that accounts for climate change, will minimize sea cliff-related impacts, and not seriously affect the structure during its expected lifetime.

c. The design life of new structures is presumed to be a minimum of 75 years. Exact future rates of accelerated sea cliff retreat are unknown and will vary among location and over time, but are currently estimated to average 12 inches per year, potentially accelerating to 1 to 3 feet per year if sea level rise progresses. Site-specific sea cliff retreat data derived from historical aerial photo review may be considered during the review of likely future project-specific sea cliff retreat impacts. Site-specific estimates of sea cliff retreat rates are to be prepared by a Registered Geologist, Engineering Geologist or other similarly qualified individual, and are subject to approval by the City.

d. The City recognizes the need for owners of threatened coastal properties to perform maintenance and modest improvements to threatened principal structures (primary living quarters, main commercial buildings, and functionally necessary appurtenances to those structures, such as septic systems and infrastructure) and other facilities. The City's goal is to minimize exposure of substantial new improvements to hazards of bluff retreat and avoid the need for installation of environmentally harmful coastal protection structures that could be requested to protect such improvements. To meet these goals, the following guidelines apply:

    i) Protection for existing structures shall first focus on techniques that avoid use of coastal protection structures including use of non-intrusive techniques such as drainage control, installation of drought tolerant landscaping, construction of cantilevered grade beam foundations, etc.

    ii) Demolition or relocation of threatened principal structures and facilities further inland on parcels shall be favored over installation of coastal protection structures.

    iii) Coastal protection structures shall not be allowed for the sole purpose of protecting accessory structures (e.g., garages, carports, storage sheds, decks, patios, walkways, landscaping).

    iv) The siting of new major improvements shall consider accelerated rates of sea cliff retreat associated with climate change-induced sea level rise as projected by the State of California, or an area- or site-specific geologic investigation that accounts for climate change.

S20.2 Shoreline Management Plan. Develop a comprehensive Shoreline Management Plan to identify, manage and to the extent feasible, mitigate or reduce climate change-induced sea level rise impacts upon public facilities and private property along the City Shoreline. The City should continue coordination with local and regional entities such as the Beach Erosion Authority for Clean Oceans and Nourishment (BEACON), the County, other South Coast cities, and UCSB to manage coastal issues including:

a. Protection/restoration of natural sand transport and sand supply replenishment projects;

b. Natural bluff restoration, stabilization and erosion control measures;

c. Non-intrusive methods to slow sand transport and retain sand along the beaches that form the City's bluffs; and

d. Funding mechanisms to implement beach replenishment and methods to reduce bluff retreat.

S20.3 Minimize Impacts to Sea Cliffs. In an attempt to impede the sea cliff retreat process, programs to control or prohibit the following activities that can significantly alter the rates of sea cliff erosion and retreat should be implemented.

a. Improper Access. Improper access may be discouraged by providing existing, established official beach access routes with additional parking, improved access facilities, and publicizing their locations. The use of unmaintained, improvised access routes that have the potential or are creating a serious erosion problem should be discouraged. This could be done by posting informational signs at the top of the cliff near the access route, describing the adverse effects that improper access can cause and where the nearest maintained access routes are located. The City will also pursue appropriate enforcement actions if new paths are created on coastal bluffs.

b. Loading. Development that will add adverse amounts of excessive weight to the top of the cliff (e.g., large structures, swimming pools, artificial fill, etc.) should be discouraged.

c. Improper Vegetation. Where feasible, existing non-native vegetation that requires large amounts of water, such as ice plant and annual grass, should be replaced with native vegetation.

d. Trash Disposal. The disposal of any material onto the face of the cliff, including brush clippings from landscape vegetation, shall be prohibited.

S21. **Development on the Bluff Face.** With the exception of drainage systems identified in Implementation Action S19.2, no development shall be permitted on the bluff face except for engineered staircases or access ways to provide public beach access and pipelines for scientific research or coastal dependent industry. To the maximum extent feasible, these structures shall be designed to minimize alteration of the bluff and beach.

Fire Hazards

S22. **Fire Hazard Reduction.** Adverse effects of fire hazards shall be reduced to the extent feasible through hazard avoidance, project design measures, compliance with regulations, and the implementation of mitigation measures as part of the development review and permitting process.

Possible Implementation Action to be Considered

S22.1 Impacts to Evacuation Routes. Development projects located in the Extreme Foothill and Foothill High Fire Hazard Zones shall be evaluated to determine if the project would have the potential to result in a significant emergency evacuation impact. A project would result in a significant evacuation impact if it would result in either of the following conditions:

a. Physically interfere with evacuation capabilities. A project could physically interfere with evacuation capabilities if it would reduce evacuation capacity by substantially decreasing the width of road or other access way, or result in the closure of a road or access way.

b. Substantially reduce evacuation capacity in the project area. A project could substantially reduce evacuation capacity if it would add a considerable amount of traffic to probable evacuation routes that do not meet current Fire Department roadway or access standards; or add a considerable amount of traffic to probable evacuation routes in relation to roadway capacity and evacuation traffic volumes reasonably expected to be generated by existing development in the project area.

S22.2 Evacuation Route Evaluation. The Fire Department should evaluate the effectiveness of existing and proposed fire emergency evacuation routes, and develop standardized mitigation measures that can be applied to projects to minimize their project-specific and cumulative evacuation-related impacts.

S22.3 Fire Department Tactical Areas. To increase fire fighter safety during wildfire emergencies, new development and major redevelopment proposals located in designated high fire hazard areas should be reviewed to assess the potential for the project to provide on-site fire suppression tactical areas, such as staging areas, safety zones and escape routes. Fire suppression tactical areas should be provided consistent with standards to be developed by the Fire Department.

S22.4 Hazard Reduction Design Requirements. Project designs shall adequately address fire hazard, providing for appropriate site layout; building design and materials; fire detection and suppression equipment; landscaping and maintenance; road access and fire vehicle turnaround; road capacity for evacuation; and water supply.

S22.5 Education and Training. The Fire Department shall continue working with the Planning Commission, Design Review Boards, and development review staff to enhance understanding and appropriate application of measures to reduce fire hazard.

S23. **Defensible Space.** Require that defensible space be provided around existing and proposed development projects located in high fire hazard areas in accordance with requirements specified by the Wildland Fire Plan, or as recommended by the Fire Department.

S24. **Vegetation Management.** Vegetation management programs to reduce fire fuel loads, as well as project-related landscape and maintenance plans, shall balance fire risk reduction benefits with possible aesthetic, habitat and erosion impacts. Impacts that have the potential to result from fuel management activities shall be avoided or reduced to the maximum extent possible.

S25. **Fire Hazard Risk Reduction.** The City will continue to implement programs that reduce the risk of wildland and structure fires, and that minimize the short- and long-term effects of fires that do occur.

Possible Implementation Actions to be Considered

S25.1 Wildfire Risk Reduction. Continue to implement risk reduction measures identified by the Wildland Fire Plan.

S25.2 Limit Residential Development in High Fire Hazard Areas. Land use map designations limit residential density in High Fire Hazard Areas. Offer incentives and/or an option for property owners to transfer development rights from the High Fire Hazard Area to the High Density residential land use designations.

S25.3 Wildland Fire Suppression Assessment District. Continue to implement wildfire risk reduction programs facilitated by the Wildland Fire Suppression Assessment District, such as vegetation management and homeowner assistance programs.

S25.4 Coordination. Continue to coordinate fire risk prevention, management, response, recovery and public education programs with the County of Santa Barbara, Montecito Fire Protection District, U.S. Forest Service, California Emergency Management Agency, CAL FIRE, Federal Emergency Management Agency and other agencies.

S26. **Post Fire Recovery.** Rebuilding that occurs in designated high fire hazard shall incorporate all applicable design measures that reduce the risk of future fire-related impacts. Expedited project review and permitting shall occur as determined by the Community Development Director.

S27. **Building Code Updates.** Periodically adopt amendments or updated provisions of the California Building Code as appropriate to implement new building design measures that minimize fire hazards to structures.

S28. **Fire Prevention and Creek Restoration.** Coordinate fire prevention and vegetation management activities with creek and riparian resource protection by developing and implementing Best Management Practices for vegetation/fuel management operations conducted within and adjacent to creek corridors.

Possible Implementation Actions to be Considered

S28.1 Vegetation Management Practices. Guidelines should be developed for conducting fuel management activities in creek areas. At minimum, the guidelines should include the following parameters:

a. Describe conditions that warrant vegetation management activities within or adjacent to creek banks.

b. Provide standard measures to minimize impacts to wetland and riparian habitat.

c. Standards for when vegetation management operations may be conducted to minimize the potential for impacts to nesting birds and sensitive species.

d. Requirements to prepare site-specific evaluations/vegetation management plans for fuel management operations that are planned to occur within or adjacent to sensitive habitat areas.

e. Requirements regarding when a Streambed Alteration Agreement (Fish and Game Code 1601) from the California Department of Fish and Wildlife is required prior to the implementation of the vegetation management work.

f. Standard mitigation measures to be implemented if planned vegetation management operations would have the potential to result in significant direct or indirect impacts to sensitive habitat, species or water quality.

S29. **Water System Improvements for Fire Fighting.** Evaluate the potential for additional water system improvements to assist in emergency preparedness and incorporate feasible measures into the City Capital Improvement Plan.

S30. **Private Water Supplies for Fire Fighting.** Encourage and assist homeowners in High Fire Hazard Areas to install their own emergency water supplies to support fire fighting operations. Assistance could include expedited permit review.

Flood Hazards

S31. **Development in Flood Hazard Areas.** Avoid placing new public and private development, substantial redevelopment or reuse projects in locations that would obstruct flood flow within a designated floodway area.

S32. **Localized Drainage Impacts.** New public and private development or substantial redevelopment or reuse projects located in areas outside a designated 100-year floodplain, but in areas known to have experienced repeated property damage to due to poor storm water drainage, shall not contribute to existing drainage impacts by substantially increasing runoff volume or flow rates, or displacing runoff onto adjacent properties.

S33. **Floodplain Mapping Update.** Coordinate with FEMA to update the Flood Insurance Rate Map (FIRM) floodplain boundaries for Special Flood Hazard Areas such as the Mission and Sycamore creek drainages and Area A near the Estero.

S34. **Dam Inundation.** Potential dam inundation hazards to new development located downstream of the Lauro Reservoir shall be considered during the development review process.

S35. **Sea Level Rise.** Monitor, assess and adapt to changes in stream and coastal flooding characteristics that may occur due a global climate change induced rise in sea level.

Possible Implementation Actions to be Considered

S35.1 Monitoring, Data Collection, and Analysis of Sea Level Rise. Develop the following data and analysis to support future sea level rise risk assessment, vulnerability analysis, and adaptation planning.

a. Tide gauge. Protect ongoing functioning of the NOAA tide gauge at the Santa Barbara breakwater to establish a long-term monitoring record of sea level changes.

b. Sea cliff monitoring. Establish a sea cliff monitoring program with surveyed transects that can be regularly monitored to document and track rates of cliff retreat.

c. Beach profiles. Establish a set of beach profiles (spaced at about 500 feet) from Leadbetter Beach to the Clark Estate, and a set of winter and summer profiles from Cabrillo Boulevard to the shoreline, for annual surveys to track seasonal and long-term changes.

d. Flooding and inundation. Obtain detailed topographic mapping of low-lying areas of the City and the Airport (accurate to at least 12 inches, such as from State LiDAR satellite survey), and develop projected future flooding and inundation area maps to assist future adaptation planning.

S35.2 Sea Level Rise Risk Assessment and Vulnerability Analysis. Conduct periodic sea level rise studies that provide risk analysis indicating probability and magnitude of future impacts to Santa Barbara due to sea level rise to support future adaptation planning. Consider effects associated with storm flooding, beach and cliff erosion, and permanent inundation. Consider short-term effects (from storms), intermediate-term effects (to 2050), and long-term effects (to 2100).

S35.3 Sea Level Rise Adaptation. Identify policy options, costs, and consequences for addressing sea level rise issues, including:

a. Techniques to minimize wave energy and damage from storm surges, while minimizing disruption of coastal activities and habitats.

b. Review of City public improvements and utilities for potential consequences of sea level rise, and consideration of means of adaptation such as measures to protect in place, raising facilities above projected flood heights, and managed retreat or relocation of facilities.

c. Coordination with private property owners along the waterfront on techniques for structural adaptation and new design.

S36. **Future Inundation.** Consider the following options in the development of adaptation plans for future permanent inundation effects:

a. Establishing mandatory rolling setbacks that move landward over time for future development or significant redevelopment in areas likely to be affected by sea level rise inundation within the expected lives of the structure.

b. Restricting rebuilding when structures are substantially damaged by sea level rise inundation and coastal storms.

c. Developing policies and identifying funding or tax incentives to relocate away from areas subject to future sea level rise inundation.

d. Evaluating the costs, impacts, and estimated lifespan of a seawall along Cabrillo Boulevard and Shoreline Drive.

Hazardous Materials

S37. **Hazardous Materials Exposure.** Seek to provide facilities and guidance so that new development and redevelopment projects avoid exposure to hazardous materials and provide for their safe disposal.

Possible Implementation Actions to be Considered

S37.1 <u>Household Hazardous Materials and Wastes</u>. Coordinate with other South Coast jurisdictions and the waste management industry to develop additional household hazardous waste collection facility capacity on the South Coast.

S37.2 <u>Pharmaceutical Waste</u>. Coordinate with other South Coast jurisdictions and the waste management industry to develop additional opportunities for residents to properly dispose pharmaceutical waste.

S38. **Exposure Risk Reduction.** The City shall continue to investigate ways to facilitate hazardous waste site remediation, protect public health, and minimize environmental impacts resulting from the presence of waste material and from remediation activities.

S39. **Integrated Pest Management.** The City shall encourage new and existing development projects to implement integrated pest management strategies that reduce the use of pesticides.

Public Safety

S40. **Electromagnetic Field Development Setbacks.** Continue application of prudent avoidance policy in siting development near transmission lines with adequate setbacks.

Possible Implementation Actions to be Considered

S40.1 <u>Monitor Electromagnetic Field Study</u>. Continue to monitor scientific study of electromagnetic fields and update development polices as necessary.

S41. **Natural Gas Transmission and Distribution Pipelines.** New development shall provide adequate setbacks from natural gas transmission and distribution pipelines to facilitate pipeline maintenance activities.

S42. **Airport Safety.** New development at the Airport shall be evaluated for compliance with the safety requirements of FAA regulations, the Santa Barbara County Airport Land Use Plan, and the City of Santa Barbara Airport Master Plan.

S43. **Hazardous Substance Transportation.** Potential health and safety impacts that could occur as a result of a hazardous substance release shall be evaluated during the environmental review of projects located adjacent to U.S. Highway 101 and the Union Pacific railroad tracks.

Public Services

S44. **City Services and Facilities.** City services and facilities shall be built, maintained and operated in a manner to provide adequate services to all residents and coexist compatibly with surrounding land uses.

Possible Implementations Actions to be Considered

S44.1 Service and Facility Performance. Monitor services and facilities and report status regularly to the City Council through the Capital Improvement Program (CIP) process.

S44.2 Financing Capital Improvements. The City shall pursue a variety of financing sources for the maintenance and enhancement of capital improvement projects.

a. Fees. Investigate increasing fees to finance the cost of capital improvements.

b. Bonds. Pursue voter approval of general obligation bonds for major capital improvements.

S45. **Safety-Related Infrastructure Improvements.** Consider improvements to infrastructure systems identified by reports and evaluations, such as the *Santa Barbara County Multi-Jurisdictional Hazard Mitigation Plan*, the *City of Santa Barbara Annex to the Multi-Jurisdictional Hazard Mitigation Plan*, and *Keeping Santa Barbara in Shape*, *Infrastructure Financing Report for the City of Santa Barbara (2008).* Infrastructure system improvements identified by these and similar evaluation programs should be considered as priorities when funding to implement infrastructure improvements becomes available.

S46. **Impacts to City-Wide Service.** Individual projects shall be evaluated for their impacts on the City's ability to provide adequate services and facilities.

S47. **Availability of Services.** Services and facilities shall be available for developments prior to issuing occupancy or use certificates.

Appendix A
Safety Element Technical Background Report

Geologic and Seismic Hazards

INTRODUCTION

The geologic and seismic conditions in and around Santa Barbara can result in a variety of hazards that can damage public and private buildings, transportation systems and utilities, and result in disruptions of service systems, substantial monetary costs, injuries, and even loss of life. The effects of geologic and seismic hazards are in large part dependent on site-specific conditions and the type of development that has occurred at that site. It is not the purpose of the Safety Element to determine how geologic or seismic hazards may affect a particular property, but rather to assist in the planning process by providing information regarding regional and local conditions, which can be used to identify general areas that may be adversely affected by geologic and seismic hazards. For example, the presumed location and activity characteristics of a fault can be used to determine its potential to result in ground rupture or ground shaking impacts at a particular project site, and certain geological formations are more prone to be associated with certain hazards such as landslides or liquefaction.

This section of the Safety Element provides a brief overview of general geologic and seismic conditions in the City of Santa Barbara, describes how hazards may affect development in the City, and identifies programs and regulations that have been implemented to minimize the effects of geologic and seismic hazards.

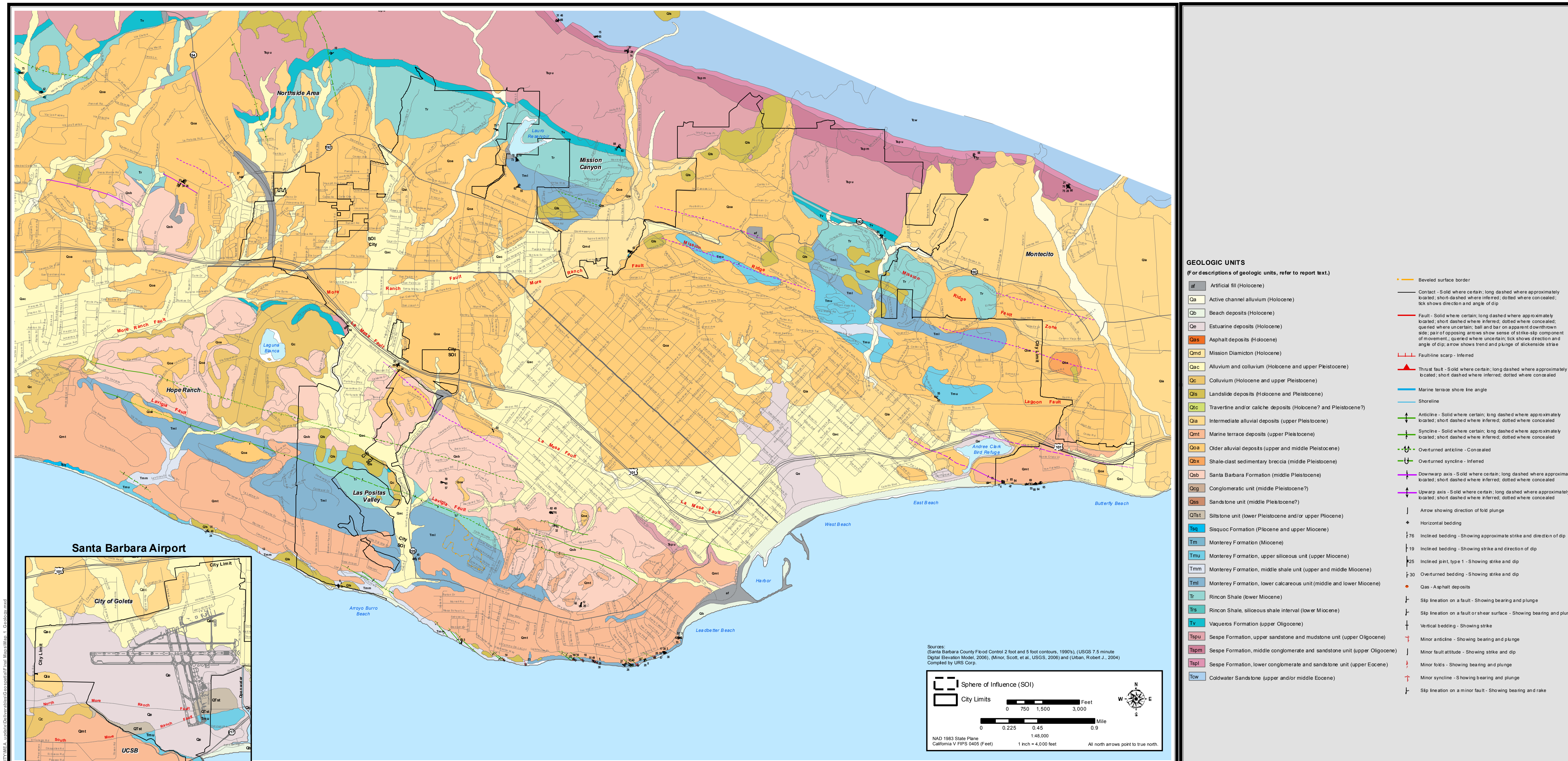
GEOLOGY AND SOILS

General Geology

Santa Barbara is located on an east-west trending coastal plain that is about three miles wide, extending between the Santa Ynez Mountains to the north and the Pacific Ocean to the south. A regional system of faults and folds collectively known as the Santa Barbara Fold Belt has modified the coastal plain and created elevated topographic features in the City such as Mission Ridge (the Riviera neighborhoods) and the Mesa. Movement along the faults and folds of the Santa Barbara Fold Belt generally occurs as a result of transferred strain originating from movement along the San Andreas fault, which is approximately 40 miles north of Santa Barbara.

Figure 2, Santa Barbara Geology, presents a map depicting the locations of the geologic formations found in Santa Barbara and the surrounding areas. As shown by Figure 2, much of the low-lying areas in Santa Barbara are covered by unconsolidated deposits of silt, sand, gravel, cobbles and boulders (alluvial material), most of which was washed down from the Santa Ynez Mountains over the past 1.8 million years. Other consolidated sedimentary geological formations found in the City include the Santa Barbara, Monterey, Rincon and Sespe Formations. The Santa Barbara Formation is the youngest of these formations and is comprised of sands and silts that were deposited between 1.8 and five million years ago. The Santa Barbara Formation can be found throughout much of the Alta Mesa neighborhood. The Monterey Shale Formation was formed between five and 23 million years ago and is predominately exposed in the sea cliffs that form the southern border of the Mesa neighborhoods, parts of the Riviera neighborhood, and the middle portion of the Las Positas area. The Rincon Shale was formed roughly between 16 and 23 million years ago and is a clay-rich formation that is also exposed in the Las Positas area, and in the Foothill and Riviera neighborhoods.

Figure 2



City of Santa Barbara
General Plan
Geology

Map prepared by URS Corporation, April 2008

The Sespe Formation is the oldest geologic formation in the City and was formed from clay and sand sediments deposited about 23 to 34 million years ago. The Sespe Formation is exposed in the Cielito neighborhood. More detailed information regarding each of the geological formations depicted on Figure 2 is provided by Appendix A of the *Geology and Geohazards Technical Report*.

Soils

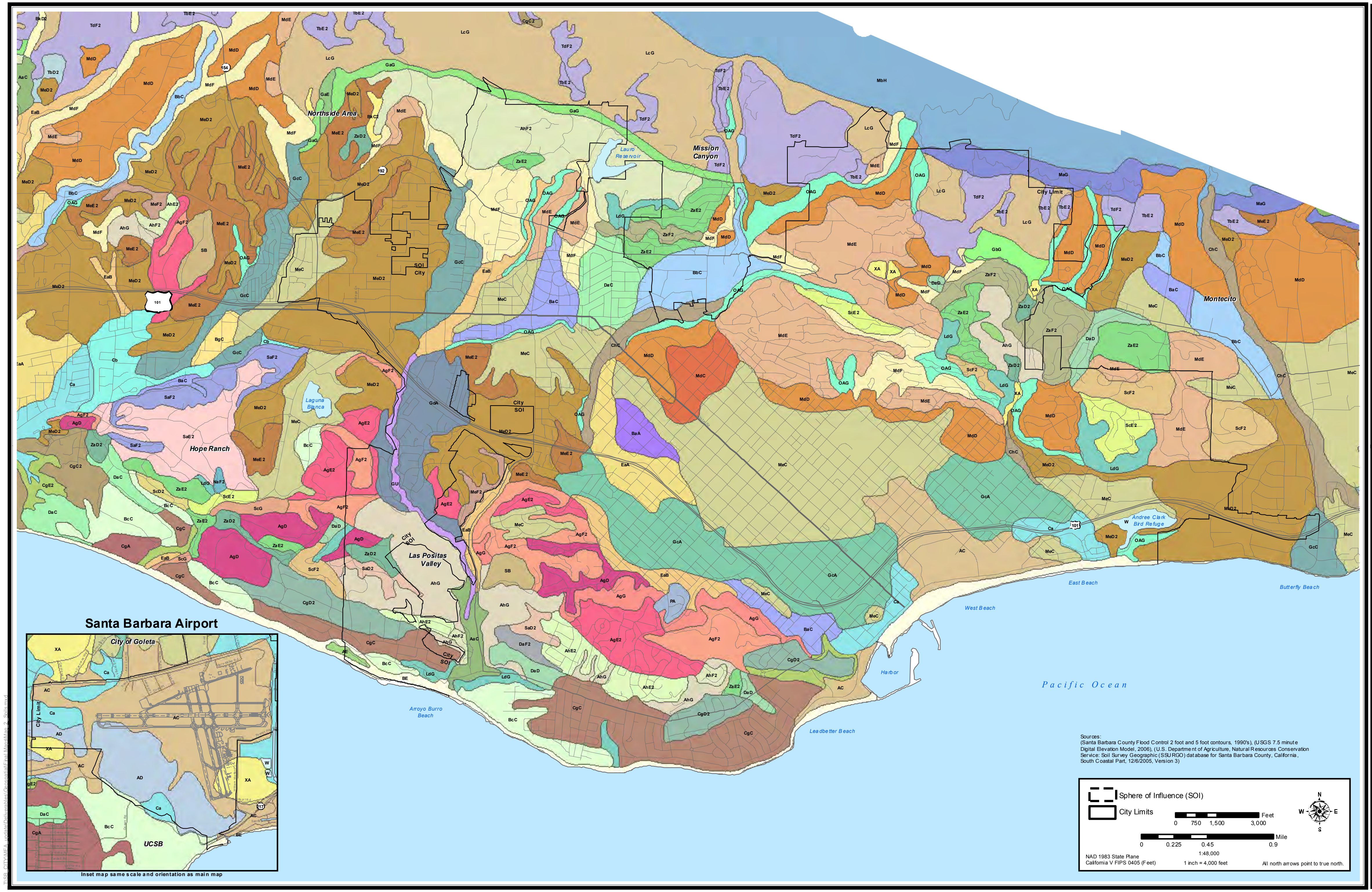
Soils in the Santa Barbara area are generally derived from parent material found in alluvial fans, floodplains and former tidal flats; elevated coastal terraces and valleys; and the foothill and mountain areas. Figure 3, Santa Barbara Soils, depicts the type and location of the various soil types found in the Santa Barbara area. As shown on Figure 3, about 90 soil types have been identified in and near the City. In addition, other areas of the City contain materials such as artificial fill, beach sand and rock outcrops.

Soils found in the City vary substantially in composition (i.e., amount of sand, clay, silt, etc.), depth, and drainage-related properties. Variations in these characteristics influence how the soils may affect urban development and behave during an earthquake. For example, soils with a high clay content may expand when wet and contract when dry, and this action can damage building foundations, walkways and other hardscapes. Unconsolidated soils can amplify the effects of ground shaking during an earthquake, and some granular soils may experience a sudden loss of strength known as liquefaction.

Additional information about the soils found in and near Santa Barbara can be obtained at the United States Department of Agriculture, Natural Resource Conservation Service website:

http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx.

Figure 3



SOIL TYPES

(For descriptions of soil units, refer to SSURGO database.)

No Data	
AC	AQUENTS, FILL AREAS
AD	AQUEPTS, FLOODED
AE	ARGIXEROLLS AND XERERTS, LANDSLIDES AREAS
AaA	AGUEDA SILTY CLAY LOAM, 0 TO 2 PERCENT SLOPES
AaC	AGUEDA SILTY CLAY LOAM, 2 TO 9 PERCENT SLOPES
AaD	AGUEDA SILTY CLAY LOAM, 9 TO 15 PERCENT SLOPES
AbC	AGUEDA-GOLETA COMPLEX, 2 TO 9 PERCENT SLOPES
Af	ARTIFICIAL FILL
AgD	ARNOLD LOAMY SAND, 15 TO 30 PERCENT SLOPES, ERODED
AgE2	ARNOLD LOAMY SAND, 30 TO 50 PERCENT SLOPES, ERODED
AgF2	ARNOLD LOAMY SAND, 50 TO 75 PERCENT SLOPES
AgG	ARNOLD LOAMY SAND, 9 TO 15 PERCENT SLOPES
AhE2	AYAR CLAY, 15 TO 30 PERCENT SLOPES, ERODED
AhF2	AYAR CLAY, 30 TO 50 PERCENT SLOPES, ERODED
AhG	AYAR CLAY, 50 TO 75 PERCENT SLOPES
BE	BEACHES
BaA	BALLARD FINE SANDY LOAM, 0 TO 2 PERCENT SLOPES
BaC	BALLARD FINE SANDY LOAM, 2 TO 9 PERCENT SLOPES
BbC	BALLARD VARIANT, STONY FINE SANDY LOAM, 2 TO 9 PERCENT SLOPES
BcC	BAYWOOD LOAMY SAND, 2 TO 9 PERCENT SLOPES
BgA	BOTELLA SHALY CLAY LOAM, 2 TO 9 PERCENT SLOPES
BgC	BOTELLA SILTY CLAY LOAM, 0 TO 2 PERCENT SLOPES
BhC	BOTELLA SILTY CLAY LOAM, 2 TO 9 PERCENT SLOPES
BkC2	BOTELLA VARIANT CLAY LOAM, 2 TO 9 PERCENT SLOPES, ERODED
BkD2	BOTELLA VARIANT CLAY LOAM, 9 TO 15 PERCENT SLOPES, ERODED
Ca	CAMARILLO FINE SANDY LOAM
Cb	CAMARILLO, VARIANT, FINE SANDY LOAM
CcF	CAPITAN COBBLY CLAY LOAM, 30 TO 50 PERCENT SLOPES
CdG	CAPITAN-ROCK OUTCROP COMPLEX, 50 TO 75 PERCENT SLOPES
CeB	CONCEPCION FINE SANDY LOAM, 0 TO 2 PERCENT SLOPES
CgA	CONCEPCION FINE SANDY LOAM, 15 TO 30 PERCENT SLOPES, ERODED
CgC	CONCEPCION FINE SANDY LOAM, 2 TO 9 PERCENT SLOPES
CgC2	CONCEPCION FINE SANDY LOAM, 2 TO 9 PERCENT SLOPES, ERODED
CgD2	CONCEPCION FINE SANDY LOAM, 30 TO 50 PERCENT SLOPES, ERODED
CgE2	CONCEPCION FINE SANDY LOAM, 9 TO 15 PERCENT SLOPES, ERODED
CgF2	CONCEPCION LOAMY SAND, 0 TO 5 PERCENT SLOPES
ChC	CORTINA STONY LOAMY SAND, 2 TO 9 PERCENT SLOPES
CkD2	CROW HILL SILTY CLAY LOAM, 15 TO 30 PERCENT SLOPES, ERODED
CkE2	CROW HILL SILTY CLAY LOAM, 30 TO 50 PERCENT SLOPES
CkF	CROW HILL SILTY CLAY LOAM, 50 TO 75 PERCENT SLOPES
CkG	CROW HILL SILTY CLAY LOAM, 9 TO 15 PERCENT SLOPES, ERODED
DU	DUNE LAND
DaC	DIABLO CLAY, 15 TO 30 PERCENT SLOPES, ERODED
DaD	DIABLO CLAY, 2 TO 9 PERCENT SLOPES
DaE2	DIABLO CLAY, 30 TO 50 PERCENT SLOPES, ERODED
DaF2	DIABLO CLAY, 9 TO 15 PERCENT SLOPES
ES	ESCARPMENT
EaA	ELDER SANDY LOAM, 0 TO 2 PERCENT SLOPES
EaB	ELDER SANDY LOAM, 2 TO 9 PERCENT SLOPES
Eb	ELDER-SOBOBA COMPLEX, 2 TO 9 PERCENT SLOPES
GU	GULLIED LAND
GaE	GAVIOTA SANDY LOAM, 30-75 PERCENT SLOPES
GaG	GAVIOTA SANDY LOAM, 9 TO 30 PERCENT SLOPES
GbG	GAVIOTA-ROCK OUTCROP COMPLEX, 50 TO 75 PERCENT SLOPES
GcA	GOLETA FINE SANDY LOAM, 0 TO 2 PERCENT SLOPES
GcC	GOLETA FINE SANDY LOAM, 2 TO 9 PERCENT SLOPES
GdA	GOLETA LOAM, 0 TO 2 PERCENT SLOPES
LaE	LINNE CLAY LOAM, 15 TO 30 PERCENT SLOPES
LaF2	LINNE CLAY LOAM, 30 TO 50 PERCENT SLOPES, ERODED
LaG	LINNE CLAY LOAM, 50 TO 75 PERCENT SLOPES
LbG	LODO-ROCK OUTCROP COMPLEX, 50 TO 75 PERCENT SLOPES
LcG	LODO-SESPE COMPLEX, 50 TO 75 PERCENT SLOPES
LdG	LOPEZ-ROCK OUTCROP COMPLEX, 50 TO 75 PERCENT SLOPES
LdH	LOPEZ-ROCK OUTCROP COMPLEX, 75 TO 100 PERCENT SLOPES
LeE2	LOPEZ-SANTA LUCIA COMPLEX, 30 TO 50 PERCENT SLOPES, ERODED
LeF2	LOPEZ-SANTA LUCIA COMPLEX, 9 TO 30 PERCENT SLOPES, ERODED
LgE2	LOS OSOS CLAY LOAM, 15 TO 30 PERCENT SLOPES, ERODED
LgF2	LOS OSOS CLAY LOAM, 30 TO 50 PERCENT SLOPES, ERODED
LhG	LOS OSOS-MAYMEN COMPLEX, 50 TO 75 PERCENT SLOPES
MaE	MAYMEN STONY FINE SANDY LOAM, 15 TO 30 PERCENT SLOPES
MaG	MAYMEN STONY FINE SANDY LOAM, 30 TO 75 PERCENT SLOPES
MbH	MAYMEN-ROCK OUTCROP COMPLEX, 50 TO 75 PERCENT SLOPES
Mc	METZ LOAMY SAND
MdC	MILPITAS STONY FINE SANDY LOAM, 15 TO 30 PERCENT SLOPES
MdD	MILPITAS STONY FINE SANDY LOAM, 2 TO 9 PERCENT SLOPES
MdE	MILPITAS STONY FINE SANDY LOAM, 30 TO 50 PERCENT SLOPES
MdF	MILPITAS STONY FINE SANDY LOAM, 9 TO 15 PERCENT SLOPES
MeC	MILPITAS-POSITAS FINE SANDY LOAM, 9 TO 15 PERCENT SLOPES, ERODED
MeD2	MILPITAS-POSITAS FINE SANDY LOAMS, 15 TO 30 PERCENT SLOPES, ERODED
MeE2	MILPITAS-POSITAS FINE SANDY LOAMS, 2 TO 9 PERCENT SLOPES
MeF2	MILPITAS-POSITAS FINE SANDY LOAMS, 30 TO 50 PERCENT SLOPES, ERODED
MgF2	MONTARA STONY CLAY, 15 TO 50 PERCENT SLOPES, ERODED
NaF2	NACIMIENTO SILTY CLAY LOAM, 30 TO 50 PERCENT SLOPES, ERODED
NbG	NACIMIENTO-LANDSLIDE COMPLEX, 30 TO 75 PERCENT SLOPES
OAG	ORTHENTS, 50 TO 75 PERCENT SLOPES
PA	PITS AND DUMPS
RA	RIVERWASH
Rb	ROCK OUTCROP-MAYMEN COMPLEX, 75 TO 100 PERCENT SLOPES
SB	SANITARY LANDFILL AREAS
SaD2	SAN ANDREAS-TIERRA COMPLEX, 15 TO 30 PERCENT SLOPES, ERODED
SaE2	SAN ANDREAS-TIERRA COMPLEX, 30 TO 50 PERCENT SLOPES, ERODED
SaF2	SAN ANDREAS-TIERRA COMPLEX, 9 TO 15 PERCENT SLOPES, ERODED
ScD2	SANTA LUCIA SHALY CLAY LOAM, 15 TO 30 PERCENT SLOPES, ERODED
ScE2	SANTA LUCIA SHALY CLAY LOAM, 30 TO 50 PERCENT SLOPES, ERODED
ScF2	SANTA LUCIA SHALY CLAY LOAM, 9 TO 15 PERCENT SLOPES, ERODED
ScG	SANTA LUCIA SHALY LOAM, 50 TO 75 PERCENT SLOPES
TaE2	TIERRA-SAN ANDREAS COMPLEX, 15 TO 30 PERCENT SLOPES, SEVERELY ERODED
TbD2	TODOS CLAY LOAM, 15 TO 30 PERCENT SLOPES, ERODED
TbE2	TODOS CLAY LOAM, 9 TO 15 PERCENT SLOPES, ERODED
TdF2	TODOS-LODO COMPLEX, 30 TO 50 PERCENT SLOPES, ERODED
XA	XERORTHENTS, CUT AND FILL AREAS
ZaD2	ZACA CLAY, 15 TO 30 PERCENT SLOPES, ERODED
ZaE2	ZACA CLAY, 30 TO 50 PERCENT SLOPES, ERODED
ZaF2	ZACA CLAY, 9 TO 15 PERCENT SLOPES, ERODED

City of Santa Barbara
General Plan
Soils

Map prepared by URS Corporation, April 2008

REGIONAL AND LOCAL FAULTS

A fault is a fracture in the earth's crust along which one side has moved relative to the other side. Movement along a fault can occur suddenly during an earthquake or very slowly in a process known as "creep." Faults can be very short or hundreds of miles long, and offset between the two sides of the fault can vary between less than an inch and hundreds of miles. Sometimes one side of the fault moves up while the other moves down (normal, reverse or thrust faults), or the two sides move horizontally in opposite directions (strike-slip faults). Some faults are well known and easy to locate by surface exposures, while others show no expression on the ground surface to reveal their presence (blind thrust faults). Figure 4, Fault Activity Descriptions, provides additional information regarding how faults are classified related to their activity, which refers to the last time movement occurred along the fault.

Regional Faults

The most recognized fault in California is the San Andreas fault, which is approximately 40 miles northeast of the City and is the boundary between two large tectonic plates: the Pacific Plate on the west side of the fault and the North American Plate on the east side. Studies of the fault have indicated that there has been about 186 miles of offset along the fault system over the past 12 million years. The Pacific and North American plates slide past each other with relative motions to the northwest and southeast, respectively. However, east of Santa Barbara there is a "kink" in the San Andreas fault commonly referred to as the "Big Bend" where the two plates do not slide past each other. In the Big Bend area the plates collide, which causes compression, folding and thrust faulting. Thrust faulting is the dominant type of fault movement that occurs in the Santa Barbara Fold Belt and in the Santa Barbara area.

Other major faults in the Santa Barbara region are also capable of causing large earthquakes. Characteristics of some of the major faults in the Santa Barbara region are provided on Table 1.

Local Faults

Figure 2, Santa Barbara Geology, depicts the location of major faults or fault systems within or near the City of Santa Barbara. A brief description of each of the faults is provided below, and Table 2 provides a summary describing the characteristics of faults located in the City.

Figure 4

FAULT ACTIVITY DESCRIPTIONS

A classification system has been devised to describe how recently movement has occurred along a fault. A system for describing when movement on a fault last occurred is important because faults that have moved in the geologically recent past are considered to be the faults most likely to move in the near future. Agencies such as the California State Mining and Geology Board and the California Geological Survey use the following terms to describe a fault's activity characteristics.

Historically Active. Faults that have had movement in the past 200 years are classified as being historically active.

Active. A fault that has moved during the Holocene epoch is considered to be an active fault. The Holocene is generally considered to have begun about 11,000 years ago.

Potentially Active. Faults that displace geologic formations of Pleistocene age but show no evidence of movement in the Holocene period can be considered to be potentially active. Pleistocene time is the period between about two million and 11,000 years ago.

Inactive. Faults that show no evidence of movement during the past two million years and show no potential for movement in the future are classified as inactive.

Table 1 - Major Faults in the Santa Barbara Region

Fault Name	Location Relative to Santa Barbara	Fault Length (miles)	Fault Activity Classification	Estimated Slip Rate (mm/yr)	Estimated Maximum Magnitude	Notes
San Andreas	The Cholame segment is 40 miles to the northeast	800 For the entire fault	Historically Active	34 on the Cholame segment	7.3 on the Cholame segment	Movement on the Cholame segment caused the 1857 Fort Tejon earthquake. Other large earthquakes have occurred on the San Andreas fault in 1906 and 1989.
Oak Ridge (Mid-Channel Segment)	14 miles to the southeast in the Santa Barbara Channel	23	Active	1.0	6.6	The offshore Mid-Channel segment of this fault is part of a larger system that extends into Ventura County
Red Mountain	2 miles to the south in the Santa Barbara Channel	24	Active	2.0	7.0	The offshore segment of this fault is part of a larger system that extends into Ventura County
North Channel Slope	8 miles to the southeast in the Santa Barbra Channel	42	Active	2.0	7.4	The offshore segment of this fault is part of a larger system that extends into Ventura County
Santa Ynez	6 miles to the north	80	Active	2.0	7.1	Movement on this fault has resulted in the uplift of the Santa Ynez Mountains
Santa Cruz Island	28 miles to the south	31	Active	1.5	7.0	This fault is part of a larger system that extends to Ventura County

Many geologists consider one or more of the following local faults to be branches or "backthrusts" to some of the major fault systems listed above.

Mission Ridge Fault System. The Mission Ridge fault system has been mapped in Santa Barbara as a zone of roughly parallel faults located in northwest portion of the City, predominately in the Eucalyptus Hill, Riviera and Cielito neighborhoods. The Mission Ridge fault is part of a larger fault system that includes the More Ranch Fault to the west, and the Arroyo Parida and Santa Ana faults to the east. The Mission Ridge segment of the fault is approximately 10.5 miles long, while the entire fault system has a length of approximately 43 miles.

Based on studies of the More Ranch segment of the Mission Ridge fault system conducted in the Ellwood Mesa of Goleta (approximately 8 miles west of Santa Barbara), there have been several earthquakes along the fault during the late Pleistocene, and it is expected that earthquakes on the Mission Ridge fault system have a return period of approximately 3,000 years. The City's 1979 Seismic Safety Element classified the Mission Ridge fault as being potentially active, but recommended that additional studies of the fault's activity be conducted. Based on recent studies, the *Geology and Geohazards Technical Report* classifies the southern branches of the Mission Ridge fault zone as being "apparently active," and the northern branch of the fault as being "potentially active." It is estimated that a 7.2 magnitude earthquake could be generated if approximately one-half of the 43-mile Mission Ridge fault system were to rupture. The 10.5-mile Mission Ridge segment of the fault system has the potential to result in an estimated 6.5 magnitude earthquake.

More Ranch Fault. The More Ranch fault is located in the northwestern part of the City and is the western segment of the Mission Ridge fault system. Branches of the More Ranch fault have been identified or are inferred to exist in the Foothill, San Roque, East San Roque, Hope and Upper State neighborhoods. The More Ranch fault is approximately 10 miles long and extends westward through the southern portion of the Santa Barbara Municipal Airport property. The City's 1979 Seismic Safety Element and the *Geology and Geohazards Technical Report* classify the More Ranch fault as an "apparently active" fault.

Mesa Fault. The Mesa fault extends between a branch of the More Ranch fault to the west and an area near Stearns Wharf to the east. The fault likely continues eastward offshore as the Rincon Creek fault. The onshore portion of the Mesa fault is approximately 4.5 miles long and is located along the base of the Mesa in the Lower West and Westside neighborhoods. Portions of the fault are also located in the West Beach, West Downtown and Hidden Valley neighborhoods. The City's 1979 Seismic Safety Element indicated that the Mesa fault was potentially active, however, the *Geology and Geohazards Technical Report* classifies the Mesa fault as being "apparently active."

Lagoon Fault. The Lagoon fault begins in Montecito about one-half mile north of the Coast Village neighborhood, and extends westward to Sycamore Creek where it bends to the northwest until it terminates near the western end of Mission Ridge. The Lagoon Fault is about 4.5 miles long and passes through the Eucalyptus Hill and Riviera neighborhoods. The City's 1979 Seismic Safety Element indicated that the Lagoon fault was potentially active, however, the *Geology and Geohazards Technical Report* classifies the Lagoon fault as being "apparently active."

Lavigia Fault. The Lavigia fault is about four miles long and extends east to west through Elings Park in the central portion of the Bel Air neighborhood, and along the southern boundary of the Hidden Valley neighborhood. The *Geology and Geohazards Technical Report* classifies the Lavigia fault as being "potentially active."

Rocky Nook Fault. The Rocky Nook fault begins in the Riviera neighborhood and extends to the northwest where it is exposed in a small bedrock exposure in Rocky Nook Park. The fault continues to the northwest where it likely links with a fault that contains possible fault slivers that pass beneath the Lauro Reservoir dam in the Foothill neighborhood. The *Geology and Geohazards Technical Report* classifies the Rocky Nook fault as being "apparently active."

Old San Marcos Fault. The Old San Marcos fault consists of three branches located northwest of the City. Two of the fault's branches are located within the City's Sphere of influence and cross State Route 154 about one mile north of the city limits. The *Geology and Geohazards Technical Report* classifies the Old San Marcos fault as being "potentially active."

Foothill Road Fault. The Foothill Road fault consists of multiple branches in a zone approximately one-half mile wide, located north of U.S. 101 and predominately west of the city limits. The *Geology and Geohazards Technical Report* classifies the Foothill Road fault as being "potentially active."

Table 2 – Summary of Major Local Faults

Fault Name	Location (Santa Barbara Neighborhoods)	Fault Length (miles)	Fault Activity Classification	Estimated Slip Rate (m/ky)(1)	Estimated Maximum Magnitude
Mission Ridge	Eucalyptus Hill, Riviera, Cielito	10.5	Apparently Active	0.3-0.4	6.5
More Ranch	Foothill, San Roque, East San Roque, Hope, Upper State and Airport	10	Apparently Active	0.3	6.4
Mesa	Lower West, Westside, West Beach, West Downtown and Hidden Valley	4.5	Apparently Active	1	6.3
Lagoon	Eucalyptus Hill, Riviera	4.5	Apparently Active	unknown	?
Lavigia	Bel Air, Hidden Valley	4	Potentially Active	0.1	6.4
Rocky Nook	Riviera, Foothill	2.5	Apparently Active	unknown	?

(1) m/ky = meters per 1,000 years

HISTORICAL SEISMICITY IN SANTA BARBARA

The City of Santa Barbara is located in a geologically complex and seismically active region, and structures in the City have been damaged by earthquake-generated ground shaking on several occasions. The most notable earthquakes to have affected the City are the great earthquakes of 1812 and 1857, and the Santa Barbara earthquake of 1925. A summary of the larger earthquakes to affect Santa Barbara during historical times is provided on Table 3, and Figure 5 provides information regarding the 1925 earthquake.

EARTHQUAKE HAZARD REDUCTION REQUIREMENTS

Numerous regulatory requirements and planning programs have been implemented at the State level to minimize the effects of faulting and seismic hazards. Some of these requirements are described below.

Alquist-Priolo Earthquake Fault Zoning Act

The 1971 San Fernando Earthquake was caused by a rupture of the San Fernando fault and resulted in the loss of many structures that had been built across the fault's path due to ground surface displacement and rupture. This earthquake demonstrated the need to avoid developing buildings across active faults and led to the passage of the Alquist-Priolo Special Studies Zone Act of 1972, which was renamed to the Earthquake Fault Zoning Act in 1994. The Act prohibits the construction of buildings for human occupancy across active faults, and structures covered by the Act must be setback from the location of the fault. A common setback distance is approximately 50 feet; however, the actual setback requirement may be increased or decreased depending on the type of structure proposed and its intended use, and the results of required site-specific investigations. There are currently no Alquist-Priolo designated Earthquake Fault Zones in the City of Santa Barbara.

Seismic Hazards Mapping Act

Extensive damage caused by ground failures during the 1989 Loma Prieta earthquake focused attention on the effects of earthquake-induced landslides and liquefaction, leading to the passage of the Seismic Hazards Mapping Act. Pursuant to the Act, the California Geological Survey is to provide local jurisdictions with Seismic Hazard Zone maps that identify areas susceptible to liquefaction, earthquake-induced landslides, and other ground failures. The Act also requires local jurisdictions to consider seismic hazard zones as part of safety planning and building permit processes. California Geological Survey Special Publication 117A, "*Guidelines for Evaluation and Mitigation Seismic Hazards in California*" provides standards of practice for geotechnical hazard investigations for construction projects located in Seismic Hazard Zones.

The Act identifies topographic map quadrangles throughout the State that are considered to be "high risk quads" and that are to be evaluated for seismic risk. The Santa Barbara quadrangle map has been identified as a "high risk quad," however, an evaluation of the area's seismic risks has not yet been completed by the California Geological Survey.

Table 3
City of Santa Barbara Historical Seismicity Summary

Date	Magnitude	Location	Description
March 24, 1806	Unknown	Unknown	Damage occurred to the Santa Barbara Mission and Presidio.
December 21, 1812	7.1	West of Ventura in the Santa Barbara Channel	Buildings at the Santa Barbara Mission sustained many cracks, and buildings at the Presidio were left uninhabitable. The church at the La Purísima (Lompoc) Mission was destroyed. One earthquake-related fatality was reported, and other fatalities were probably avoided due to a strong foreshock about 15 minutes before the main earthquake. A tsunami may have occurred at Refugio Canyon.
January 9, 1857	7.9	San Andreas fault, Cholame segment	This earthquake ruptured approximately 186 miles of the San Andreas fault. Ground fissures, liquefaction-related "sand blows" and changes in the flow of springs were observed in Santa Barbara. Strong earthquake-related shaking lasted from one to three minutes throughout affected areas.
July 27, 1902	6.0 (?)	Los Alamos	Several strong earthquakes caused extensive damage to oilfield equipment in the Los Alamos area. Shaking occurred in Santa Barbara but no damage was reported.
June 29, 1925	Both 6.3 and 6.8 are reported	Santa Barbara	Property damage was estimated at eight million dollars and 13 people were killed. The Sheffield Reservoir earthen dam was destroyed but the released water caused little damage. Most of buildings along State Street built on fill material were destroyed or had to be razed. Structures built on solid ground generally experienced little damage.
June 29, 1926	5.5 (?)	Santa Barbara	Considered to be an aftershock of the 1925 earthquake. Damage in Santa Barbara was generally light and buildings reconstructed after the 1925 earthquake experienced little damage. One child was killed by a falling chimney.
November 4, 1927	7.1	Off Point Arguello	The most severe damage occurred in northern Santa Barbara and southern San Luis Obispo Counties. A tsunami was recorded on tide gages in San Francisco and San Diego, and five–foot high waves were observed at Pismo, Port San Luis and Surf.
June 30, 1941	5.9	Offshore Carpinteria	Moderate damage in Santa Barbara and Carpinteria consisting mostly of broken windows, cracked plaster, severed water mains, and broken bottles in stores.
July 21, 1952	7.3	Kern County	Slight damage to buildings in Santa Barbara.
Summer of 1968	5.2	Santa Barbara Channel	An earthquake swarm, or a sequence of earthquakes which are temporarily and spatially related without an earthquake of outstanding magnitude, occurred in the east part of the Santa Barbara Channel. The swarm consisted of 63 earthquakes, the largest of which was magnitude 5.2 and occurred on July 4.
August 13, 1978	5.9	Off Goleta Point	Most of the damage from this earthquake occurred at UCSB, causing about 3.4 million dollars of damage to 10 major on-campus buildings.

Figure 5

1925 SANTA BARBARA EARTHQUAKE

The Santa Barbara Mission was damaged by the 1812 earthquake and rebuilt by 1820. The 1925 earthquake caused the extensive damage shown in this photograph.

The California Hotel opened four days before the earthquake and experienced heavy damage to brick walls that were not securely tied to the building. Some occupants left the building by lowering themselves to the street using bed sheets.

Many of the unreinforced masonry buildings along State Street were damaged or destroyed.

The earthquake occurred on June 29, 1925 at 6:44 a.m. and was caused by movement on a fault located in the Santa Barbara Channel. Santa Barbara had a population of about 25,000 in 1925, and the earthquake resulted in 13 fatalities. The number of casualties was probably reduced due to the early hour that the earthquake occurred.

No foreshocks were reported before the earthquake, however a water system pressure gauge recording card showed disturbances beginning at 3:27 am, which were likely caused by foreshocks. Then City Manager Herbert Nunn reported noticing a strong smell of oil at the beach soon before the earthquake occurred.

It was reported that strong ground shaking caused by the earthquake lasted 19 seconds, and four strong aftershocks occurred within 20 minutes after the quake. Additional aftershocks occurred for a year after the main earthquake. After the major shaking subsided, many of the buildings in the City's business district were destroyed or severely damaged. Unlike the 1906 San Francisco earthquake where much of the damage to the city was caused by the subsequent fire, gas and electrical power to Santa Barbara was turned off soon after the earthquake. Since no fires occurred after the Santa Barbara earthquake, the destructive force of the groundshaking could be clearly seen.

Most of the homes in the City experienced only minor damage, such as broken brick chimneys. Historian Walker A. Tompkins noted that after the earthquake one thing became obvious, "*the quake destroyed the shoddy and left the substantial*." Newer buildings in the City that survived the earthquake included the Lobero Theater, Masonic Temple, the Daily News Building (the News Press Building), City Hall, the El Paseo and Presidio complexes, the main post office at State and Anapamu Streets (now the Art Museum), and Santa Barbara High School.

After the earthquake, the City embarked on a major reconstruction effort. As part of this program, policies were adopted to promote the construction of buildings in the Spanish Colonial Revival style. As a result, the earthquake had a substantial effect on the appearance of Santa Barbara today.

Photo Source: UCSB Institute for Crustal Studies

Real Estate Disclosure Requirements

The Natural Hazards Disclosure Act requires sellers of real property to provide prospective buyers with a "Natural Hazard Disclosure Statement" when the property is located in a Seismic Hazard Zone or an Earthquake Fault Zone. California State law also requires that when houses built before 1960 are sold, the seller must provide the buyer a completed earthquake hazards disclosure report, and a copy of the booklet entitled "*The Homeowner's Guide to Earthquake Safety*." The booklet contains a sample of a residential earthquake hazards report that buyers are required to fill in, and it provides specific information on common structural weaknesses that can fail and damage homes during earthquakes.

Building Codes

The Uniform Building Code was a model building code published approximately every three years until 1997 when it was replaced in 2000 by the International Building Code. In 2010, the California Building Standards Commission adopted the 2009 International Building Code, as amended, which became the 2010 California Building Standards Code. This Code is commonly referred to as the California Building Code (California Code of Regulations, Title 24). Development in the State must comply with the requirements of the California Building Code as amended and adopted by local jurisdictions. The California Building Code, plus local amendments, is adopted by the City of Santa Barbara by Municipal Code Section 22.04.

Unreinforced Masonry Law

The Unreinforced Masonry Law of 1986 required all cities and counties in Seismic Zone 4 (zones near historically active faults) to identify potentially hazardous unreinforced masonry buildings in their jurisdictions, establish a loss reduction program, and report their progress to the State by 1990. The Unreinforced Masonry Law program was implemented in Santa Barbara under the requirements of Municipal Code Section 22.18.

California State Multi-Hazard Mitigation Plan

The purpose of this Plan is to significantly reduce deaths, injuries and other disaster losses caused by natural and human-caused hazards, including earthquakes. California is required to have a Federal Emergency Management Agency-approved multi-hazard mitigation plan to be eligible for disaster recovery assistance and mitigation funding, and it is required that the Plan be updated every three years. The Plan is also used to coordinate the preparation of *Santa Barbara County Multi-Jurisdictional Hazard Mitigation Plan.*

GROUND RUPTURE

Description of the Hazard

Seismically induced ground rupture is a break or deformation of the ground surface resulting from movement along a fault. Primary fault rupture refers to cracking and offset of the ground surface along a rupturing fault during an earthquake. As the rupture reaches the ground surface, it may spread out into complex patterns of secondary faulting and ground deformation.

Ground rupture generally results in a small percentage of the total damage caused by an earthquake, but structures affected by primary ground rupture are usually severely damaged. Ground rupture can also result in the alteration of surface drainage patterns, changes in ground water levels, and changes to the gradient of the ground surface. Offset of the ground surface caused by fault rupture can range from several inches to tens of feet, therefore, it is typically not practical or feasible to reduce damage to structures caused by ground rupture through engineering design. The avoidance of areas that may be affected by primary ground rupture is generally the most appropriate risk reduction measure. Ground surface displacement and distortion associated with secondary faulting can be relatively minor or can be large enough to cause significant damage to structures.

Local Conditions

Faults located in the City of Santa Barbara and within the City's sphere of influence were identified by the *Geology and Geohazards Technical Report*, and are depicted on Figure 6, Fault Hazard Zones. This figure shows the location or suspected location of known faults, and also depicts a 200-foot buffer area around each fault (100 feet on each side of the fault). The purpose of the buffer area is to accommodate possible variations in the location of the fault when its location is not certain, to include possible splays of the fault that could result in secondary fault rupture impacts, and to identify areas where fault location investigations may be required for proposed development projects.

Active Faults

Faults considered to be active have the highest risk of causing ground rupture-related impacts. Faults identified by the *Geology and Geohazards Technical Report* as being active for planning purposes include the:

- ***Mission Ridge, Lagoon and Rocky Nook faults***, which are primarily located in the Riviera area of the City.
- ***More Ranch fault***, located predominately in the Upper State area and at the Airport.
- ***Mesa fault,*** located predominately in the Westside area, but also in portions of the Downtown and Waterfront areas.

Potentially Active Faults

Faults considered to be potentially active have a reduced risk of ground rupture when compared to the risk presented by active faults. Faults located in the City considered to be potentially active for planning purposes include the:

- Northern branch of the Mission Ridge fault in the Cielito neighborhood.
- Lavigia fault in the Hidden Valley neighborhood.
- Small unnamed faults observed in the coastal bluffs in the Mesa neighborhood.

Hazard Reduction

The *Geology and Geohazards Technical Report* provides recommendations regarding the evaluation of proposed development projects for possible ground rupture hazards. The *Technical Report* specifies what type of fault investigations should be conducted for various types of development projects located within the fault hazard zones identified on Figure 6. It is the objective of the *Technical Report* preparation guidelines to evaluate the potential for ground rupture hazards so that if necessary appropriate risk avoidance or reduction measures can be implemented. The hazard reduction guidelines provided by the *Technical Report* are summarized below. Please refer to the *Geology and Geohazards Technical Report* for a complete description of the recommended hazard evaluation and study requirements.

The *Geology and Geohazards Technical Report* indicates that the California Building Code (Title 24) defines "essential facilities" to include facilities such as schools, hospitals, police and fire stations. The *California General Plan Guidelines* (2003) defines "critical facilities" as "*facilities that either (1) provide emergency services or (2) house or serve many people who would be injured or killed in case of disaster damage to the facility. Examples include hospitals, fire stations, police and emergency services facilities, utility facilities, and communications facilities*." In most cases, it would be appropriate to conduct project site fault investigations for land uses referred to as "essential" and "critical" facilities.

Additional guidelines and investigation requirements for development/remodeling of schools are published by the State of California General Services Department, Division of the State Architect. Similarly, investigations of sites for hospitals and certain health care facilities are subject to requirements by the State of California Office of Statewide Health Planning and Development.

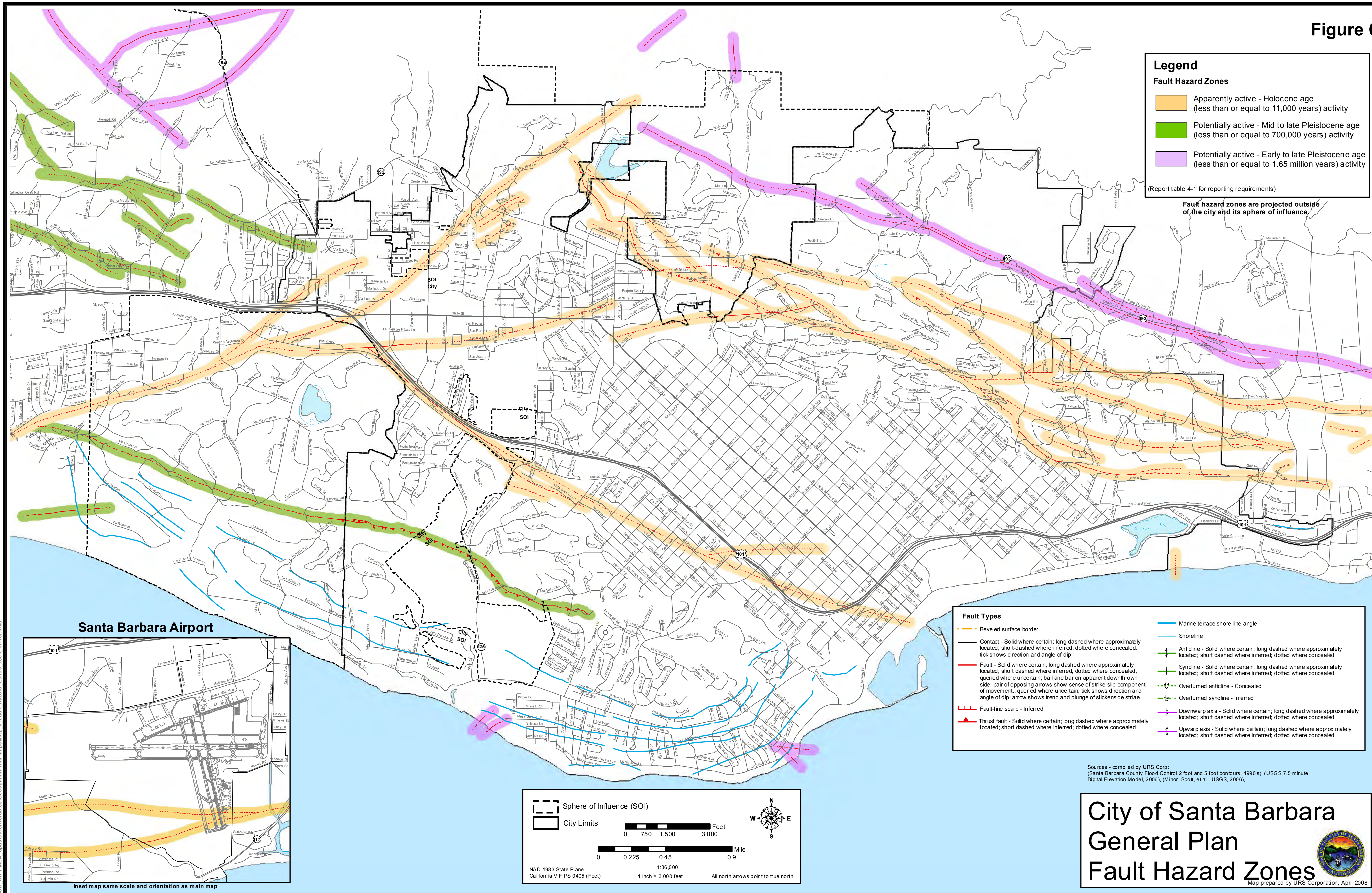


Figure 6
Legend
Fault Hazard Zones
Apparently active - Holocene age (less than or equal to 11,000 years) activity
Potentially active - Mid to late Pleistocene age (less than or equal to 700,000 years) activity
Potentially active - Early to late Pleistocene age (less than or equal to 1.65 million years) activity
(Report table 4-1 for reporting requirements)
Fault hazard zones are projected outside of the city and its sphere of influence.
Fault Types
Beveled surface border
Contact - Solid where certain; long dashed where approximately located; short-dashed where inferred; dotted where concealed; tick shows direction and angle of dip
Fault - Solid where certain; long dashed where approximately located; short dashed where inferred; dotted where concealed; queried where uncertain; ball and bar on apparent downthrown side; pair of opposing arrows show sense of strike-slip component of movement,; queried where uncertain; tick shows direction and angle of dip; arrow shows trend and plunge of slickenside striae
Fault-line scarp - Inferred
Thrust fault - Solid where certain; long dashed where approximately located; short dashed where inferred; dotted where concealed
Marine terrace shore line angle
Shoreline
Anticline - Solid where certain; long dashed where approximately located; short dashed where inferred; dotted where concealed
Syncline - Solid where certain; long dashed where approximately located; short dashed where inferred; dotted where concealed
Overturned anticline - Concealed
Overturned syncline - Inferred
Downwarp axis - Solid where certain; long dashed where approximately located; short dashed where inferred; dotted where concealed
Upwarp axis - Solid where certain; long dashed where approximately located; short dashed where inferred; dotted where concealed
Sources - complied by URS Corp:
(Santa Barbara County Flood Control 2 foot and 5 foot contours, 1990's), (USGS 7.5 minute Digital Elevation Model, 2006), (Minor, Scott, et al., USGS, 2006),
Sphere of Influence (SOI)
City Limits
Feet
0 750 1,500 3,000
Mile
0 0.225 0.45 0.9
NAD 1983 State Plane
California V FIPS 0405 (Feet)
1:36,000
1 inch = 3,000 feet
All north arrows point to true north.
N
E
S
W
Santa Barbara Airport
Inset map same scale and orientation as main map
City SOI
101
154
192
225
217
City of Santa Barbara
General Plan
Fault Hazard Zones
Map prepared by URS Corporation, April 2008

Active Faults

Screening Level Fault Investigations[1] should be prepared for non-exempt[2] single-family residential units, residential projects with more than four units, and multi-family residential projects.

Project Site Fault Investigations[3] should be conducted for commercial, industrial and essential/critical facility projects located within designated zones for the More Ranch, Mission Ridge, Lagoon, and Rocky Nook faults.

Potentially Active Faults

Figure 2, Santa Barbara Geology, depicts two classifications of potentially active faults. Faults that demonstrate movement between 11,000 and 700,000 years ago are highlighted in green and include the Lavigia and Foothill Road faults. Faults that demonstrate movement between 11,000 and 1.65 million years ago are highlighted in purple and include the north branch of the Mission Ridge fault and the Old San Marcos fault. The *Geology and Geohazards Technical Report* recommendations for conducting fault investigations for both fault classifications are summarized below.

Screening level fault investigations should be conducted for non-exempt single-family residential, multiple (four or fewer) single-family and multi-family residential, and commercial/industrial projects located within designated fault zones for the Lavigia and Foothill Road faults.

Project site fault investigations should be prepared for essential/critical facilities located within designated fault zones for the Lavigia, Foothill Road, north branch of the Mission Ridge, and Old San Marcos faults.

For projects identified as having the potential to be adversely impacted by a primary fault rupture hazard, hazard reduction measures will generally consist of providing an appropriate setback between the fault and the proposed structure. For linear structures such as pipelines that must cross the fault, appropriate mitigation may include providing shut-off valves on both sides of the fault. For secondary fault rupture impacts, appropriate hazard reduction measures may include appropriate structural engineering to accommodate anticipated levels of ground movement or surface warping. It is anticipated that all proposed mitigation measures will be recommended based on the results of site-specific fault investigations and comply with appropriate engineering practices.

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[1] Screening level investigations will often include a review of available reports and data, air photo interpretation, and geologic reconnaissance. Based on the information obtained from these types of information sources, it may be determined that a site investigation is warranted.

[2] Exempt projects include projects with four or fewer wood- or steel-frame single family dwellings not exceeding two stories; wood- or steel-frame single family dwellings on parcels with prior acceptable geologic reports; condominium conversions; and small additions to existing structures not exceeding 50 percent of the existing structure value.

[3] Project site investigations are to follow California Geological Survey requirements specified in Special Note 49, and include field investigation, laboratory testing and geological analysis.

GROUND SHAKING

Description of the Hazard

Sudden movement along all or part of a fault releases accumulated strain and energy and the released energy radiates through the ground in all directions in the form of earthquake waves. As the waves pass through an area, they produce the shaking effects that are the predominant cause of earthquake damage. Earthquake-related groundshaking can also result in a various ground failure impacts such as liquefaction and slope instability.

The effects of earthquake-induced groundshaking at a particular site are a function of many factors. Some of the factors that influence the intensity of groundshaking are briefly described below.

Earthquake Magnitude

Earthquake magnitude is an indication of the amount of energy released by an earthquake. As an earthquake's magnitude increases, the potential for strong groundshaking will also increase. Additional information regarding how earthquake magnitudes are determined is provided on Figure 7.

There is usually a direct correlation between the length of a fault and the maximum magnitude earthquake that the fault is capable of producing - as the fault rupture length increases, the amount of energy released and the earthquake magnitude will also increase. Therefore, longer faults often have the capability of producing higher magnitude earthquakes than shorter faults.

Distance from the Epicenter

Groundshaking intensity generally diminishes as the distance from the earthquakes epicenter increases, but exceptions to this relationship occur. For example, the fault rupture that caused the 7.1 magnitude Loma Prieta earthquake occurred in an area near the City of Santa Cruz, but extensive groundshaking damage occurred in the Marina District in the City of San Francisco, more than 60 miles north of the earthquake epicenter. Variations in the epicenter distance/intensity relationship can be caused by a variety of factors, such as the manner in which the earthquake waves were generated, the depth at which the fault rupture occurred, characteristics of the earth's crust between the epicenter and the area where shaking was experienced, local soil conditions, and the directions that the seismic waves travelled.

Duration of Strong Shaking

Larger earthquakes generally have a longer duration of strong shaking than smaller earthquakes. The duration of shaking plays a major role in determining the amount of structural damage and potential for ground failure.

Local Geologic Conditions

Geologic conditions such as the presence of loose sediment or weathered rock will cause the travel speed of seismic waves to slow, causing the wave's energy to be converted from speed to amplitude, which will increase the effects of shaking at the site. The thickness, density and consistency of the soil, as well as the presence of shallow groundwater also have the potential to amplify the effects of groundshaking.

Figure 7

HOW EARTHQUAKES ARE MEASURED

Earthquakes are measured in terms of their magnitude and intensity. Magnitude refers to the size of an earthquake or the amount of energy released when movement along the fault occurred. The earthquake's intensity describes its effects in a given area. Although several methods have been developed to measure earthquake magnitude, typically only one magnitude is attributed to an earthquake. However, the same earthquake can have a wide range of intensities due to variations in local geologic conditions and structure characteristics.

The **Richter scale** was developed in 1932 by Charles Richter and earthquake magnitudes were calculated based on the maximum amplitude registered on a standard seismogram. Magnitude measurements using this system were based on one aspect of the seismogram, which limited the ability to measure the power of large earthquakes.

The **moment magnitude scale** was developed in 1978 and is the scale most commonly used today. The moment magnitude scale is related to the physical size of the fault rupture and movement across the fault, which provides a uniform measure of the strength of an earthquake. Similar to the Richter scale, the moment magnitude scale is a logarithmic scale so a magnitude 6.0 earthquake releases 32 times more energy than a magnitude 5.0 and nearly 1,000 times more energy than a 4.0. That does not mean, however, that the ground shakes a thousand times harder in a 6.0 than a 4.0 earthquake because the energy of the larger earthquake is released over a wider area.

Many scales have been developed to describe the intensity of an earthquake, but they are generally based on observed effects at a particular site. In the United States, the **Modified Mercalli** is the most commonly used earthquake intensity scale. This scale is general in nature and provides a description of earthquake effects ranging from Roman numeral "I" (felt by very few individuals) to "XII" (damage is total).

Building Construction

The construction characteristics of buildings, such as its size and height, materials and construction methods, will substantially influence how the building responds to the effects of groundshaking. Generally, small, well-constructed one- and two-story wood and steel frame buildings have performed well in earthquakes because of their light weight and flexibility. Several design characteristics for small wood frame buildings can, however, result in an increased potential for damage during earthquakes. These characteristics include structures that are not adequately tied to their foundation; and "soft-story" buildings, such as two-story residences that do not provide adequate bracing for the upper level of the building. For example, structural development above a garage may not have adequate lateral support because in essence the garage only provides three support walls instead of four. Reinforced concrete structures will also usually perform well. Buildings constructed from non-flexible materials, such as unreinforced brick, concrete or adobe are more vulnerable to damage caused by groundshaking. Unreinforced masonry buildings are prone to failure in large earthquakes due to inadequate anchoring of the walls to the roof and floor, lack of structural reinforcement in brittle or non-ductile building materials, and sometimes poor construction workmanship. In addition to a building's construction methods, every structure has its own fundamental period or natural vibration characteristics. If vibrations caused by groundshaking coincide with the natural vibration period of a structure, damage to the structure can be greatly increased.

Ground Acceleration

While magnitude is a measurement of the amount of energy released by the earthquake, ground acceleration is a measurement of how fast the ground moves at a given location. Two different methods have been developed to predict possible ground shaking hazards at a particular location based on ground acceleration characteristics. The first method is a deterministic ground shaking hazard evaluation, which will estimate the peak ground acceleration produced by an earthquake of a specified magnitude on a particular fault, such as a 7.0 magnitude earthquake on the San Andreas fault. This type of analysis is generally based on observations of damage from past earthquakes. The second method is a probabilistic evaluation, which will describe the likelihood of peak ground acceleration exceeding a specified level due to an earthquake in a given region over a set period of time. For example, a probabilistic analysis may indicate that there is a ten percent chance of peak ground acceleration exceeding 0.5g in the next 50 years at a given site.

The United States Geological Survey indicates that a ground acceleration of 0.10g may be an approximate threshold of damage for older (pre-1965) dwellings or dwellings not made to resist earthquakes. Some post-1985 dwellings that were built to California earthquake standards have experienced severe shaking (0.6g) with only chimney damage and damage to building contents.

Local Conditions

Earthquake-generated groundshaking has the potential to result in significant life, safety and property damage impacts in Santa Barbara, and groundshaking may be caused by movement along a fault located in or near the City, or from a more distant fault. The United States Geological Survey's Probabilistic Seismic Hazard Assessment model (2009) indicates that there is a 60-80 percent probability that the Santa Barbara area will be affected by a magnitude 5.0 or greater earthquake in the next 50 years. The model also indicates that there is a 50-60 percent chance of a 6.0 magnitude earthquake and a 15-20 percent chance of 7.0 magnitude earthquake occurring in the next 50 years.

Estimates of groundshaking intensity that could occur in Santa Barbara are provided by the *Geology and Geohazards Technical Report* and were estimated using a probabilistic seismic hazard assessment model developed by the United States Geological Survey. The seismic ground motion map provided by the *Geology and Geohazards Technical Report* is provided as Figure 8, Peak Ground Acceleration, and depicts peak ground accelerations anticipated to occur with a 10 percent chance of exceedance within a 50-year period.

In general, peak ground acceleration values depicted on Figure 8 are highest in the eastern portion of the City and lowest in the western portion. The highest estimated peak ground acceleration of 0.538g would occur in the Coast Village neighborhood, and the lowest peak ground acceleration of 0.408g is predicted to occur in the Campanil neighborhood. Predicted peak ground accelerations at the Santa Barbara Municipal Airport range from 0.403g to 0.416g. Although there is some variation in anticipated peak ground acceleration values throughout the City, all of the reported values have the potential to result in substantial damage to buildings and structures. Additional information detailing how the peak ground acceleration values depicted on Figure 8 were derived is provided by the *Geology and Geohazards Technical Report*.

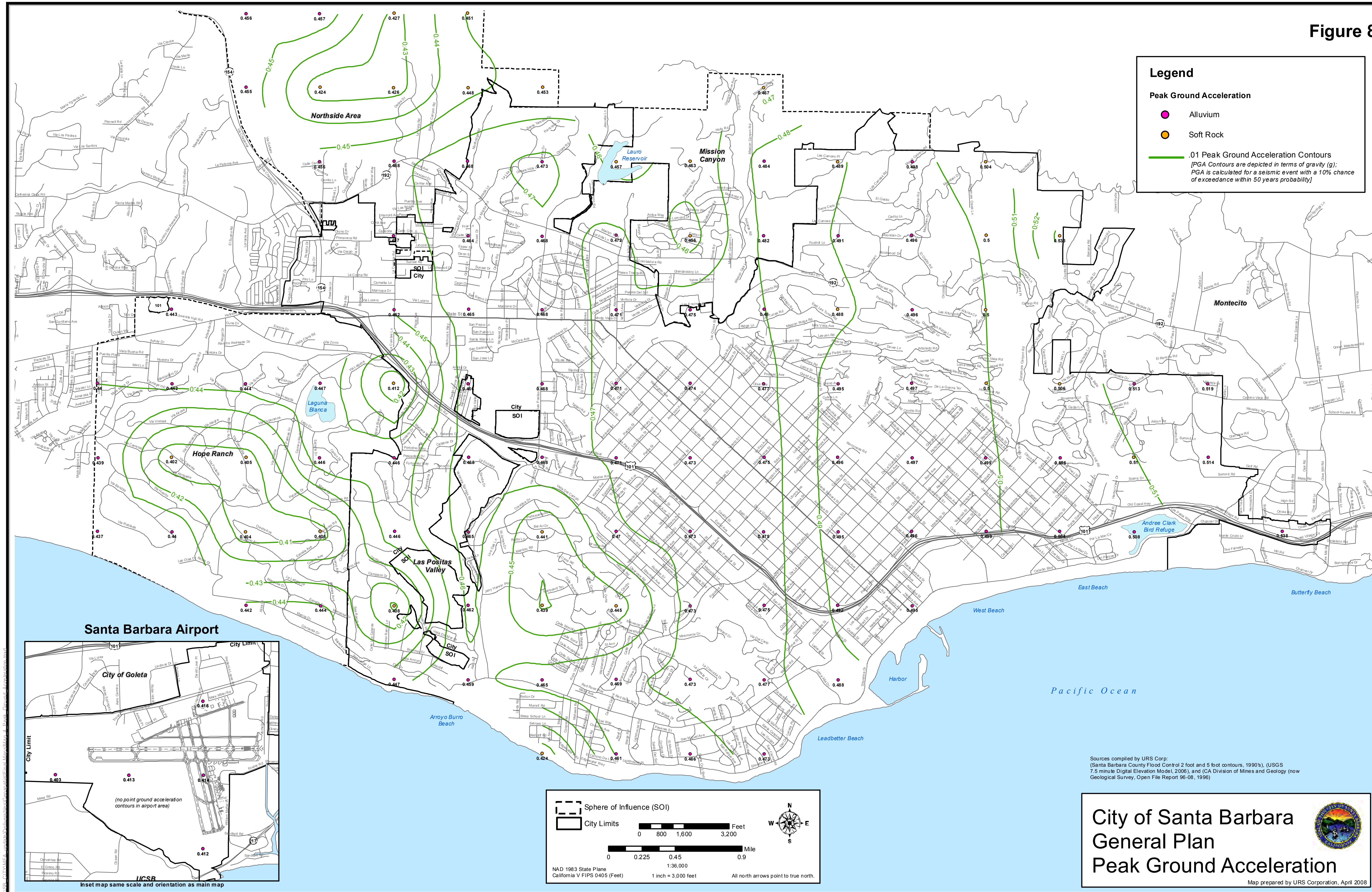


Figure 8
Legend
Peak Ground Acceleration
Alluvium
Soft Rock
.01 Peak Ground Acceleration Contours
[PGA Contours are depicted in terms of gravity (g); PGA is calculated for a seismic event with a 10% chance of exceedance within 50 years probability]
Northside Area
Mission Canyon
Lauro Reservoir
Montecito
Hope Ranch
Laguna Blanca
Las Positas Valley
Arroyo Burro Beach
Leadbetter Beach
West Beach
East Beach
Butterfly Beach
Harbor
Andree Clark Bird Refuge
Pacific Ocean
Santa Barbara Airport
City of Goleta
City Limit
UCSB
(no point ground acceleration contours in airport area)
Inset map same scale and orientation as main map
Sphere of Influence (SOI)
City Limits
Feet
0 800 1,600 3,200
Mile
0 0.225 0.45 0.9
1:36,000
1 inch = 3,000 feet
NAD 1983 State Plane California V FIPS 0405 (Feet)
All north arrows point to true north.
Sources compiled by URS Corp: (Santa Barbara County Flood Control 2 foot and 5 foot contours, 1990's), (USGS 7.5 minute Digital Elevation Model, 2006), and (CA Division of Mines and Geology (now Geological Survey, Open File Report 96-08, 1996)
City of Santa Barbara
General Plan
Peak Ground Acceleration
Map prepared by URS Corporation, April 2008

Hazard Reduction

Substantial changes and refinements have been made to the California Building Code (CCR, Title 24) to reduce the potential for structural damage during earthquakes. The California Building Code provides seismic design requirements for general structures in the State and requires that they be able to accommodate seismic ground motions generated by a Design Basis Earthquake, defined as the earthquake with a 10 percent chance of being exceeded within a 50 year period (the ground acceleration values depicted on Figure 8). The California Building Code also requires that "essential facilities" be designed to resist structural collapse resulting from ground motions produced by an earthquake with a 10 percent chance of exceedance within a 100-year period.

The 2011 Santa Barbara Annex to the *Multi-Jurisdictional Hazard Mitigation Plan* includes recommended mitigation actions to reduce risks created by geologic hazards, including the effects of groundshaking, and to ensure that critical services and facilities survive a disaster. The mitigation actions recommended by the Santa Barbara Annex for specified facilities are reviewed and revised at least every five years to reflect updated hazard reduction information, priorities and funding constraints. The mitigation actions recommended by the 2011 Santa Barbara Annex are related to reducing groundshaking hazards to City-owned facilities, including the: police station; Laguna pump station; seismic renovations to Harbor facilities; and strengthening existing gravity/unreinforced retaining walls adjacent to roadways in high fire hazards areas in the City.

The *Geology and Geohazards Technical Report* provides recommendations for assessing the potential for groundshaking hazards on proposed development projects. The *Technical Report* indicates that the peak ground acceleration values depicted on Figure 8 should only be used in preliminary site assessment or planning efforts, and that site-specific evaluation of design earthquake ground acceleration values should be required for minor improvement, all residential, commercial/industrial, and essential/critical facility projects.

The City of Santa Barbara has implemented several programs to minimize potential structural damage impacts during earthquakes. Municipal Code Section 22.18 requires that unreinforced masonry buildings be retrofitted to reduce the danger of collapse during earthquakes. The Building and Safety Department estimates that 256 buildings, located mostly in the Downtown area have been upgraded. From time to time, however, additional safety issues associated with unreinforced buildings are discovered and those issues are rectified upon discovery consistent with City and State requirements. The Building and Safety Department has also implemented a "prescriptive seismic strengthening" program consistent with the California Building Code. This voluntary program assists homeowners in making seismic safety improvements to their residences, which often includes improvements to tie the structure to its foundation.

LIQUEFACTION

Description of the Hazard

Liquefaction is a temporary loss of soil strength that can occur during moderate to large earthquakes. Three conditions must be present for liquefaction to occur: affected soils must be comprised of granular material such as sand or silt-sized particles; the soil must be saturated by groundwater; and the soil must be relatively loose or cohesionless.

Soil consists of individual particles, each of which is in contact with adjacent particles. The weight of the overlying soil particles produces contact forces between particles, which holds individual particles in place and gives the soil its strength. Liquefaction occurs when force (i.e., earthquake groundshaking) is applied to loose, granular, saturated soil and the individual particles attempt to move into a more-dense configuration. During an earthquake, however, there is not adequate time for the water in the pore spaces between soil particles to be squeezed out, which prevents the soil particles from moving closer together. This is accompanied by an increase in water pressure, which reduces the contact forces between individual soil particles, resulting in a weakening of the soil. The water pressure between soil particles may become so high that many of the particles lose contact with each other. When this occurs, the soil will have little strength and will behave more like a fluid rather than a solid.

Of the three conditions that must be present for liquefaction to occur, saturation of soil by groundwater is the condition that has the potential to change over time, particularly in response to seasonal fluctuations in groundwater levels. A short- or long-term increase in groundwater levels, in both shallow "perched" groundwater sources or in deeper aquifers, could have the potential to increase the occurrence and severity risk of liquefaction. Areas with shallow groundwater have a higher risk for liquefaction to occur, and in general, liquefaction risk is considered to be low when groundwater levels are more than about 60 feet below the ground surface. In areas with groundwater shallower than 60 feet, the liquefaction hazard may or may not be present, depending on the size, distribution and cohesion of soils.

Liquefaction can result in several types of ground failures. Lateral spreading results in the displacement of blocks of solid soil on the ground surface due to the liquefaction of a subsurface soil layer. A flow failure occurs in a sloping area when liquefied soil or blocks of solid material are carried by a subsurface layer of liquefied soil. This type of failure can occur in areas that have a slope gradient as little as three percent and saturated, non-cohesive materials that may be deeper than 60 feet. Ground oscillation may result when liquefaction occurs at depth in a relatively level area, causing solid blocks of soil to move back and forth in the liquefied zone. The resulting ground oscillation may result in the creation of fissures and the formation of sand "volcanoes." Ground lurching occurs when saturated soils move in a wave-like manner in response to intense ground shaking.

Liquefied soil will have a substantial loss of bearing strength, which may cause buildings in affected areas to settle or tilt. The resulting structural damage can range from minor to complete failure. Depending upon buoyancy differences between the liquefied soil and lightweight or unanchored underground structures such as pipelines, underground structures may float upward to the ground surface.

Local Conditions

The potential for liquefaction to occur in Santa Barbara was evaluated by the *Geology and Geohazards Technical Report*, and that hazard assessment was predominately based on the identification of areas with non-cohesive granular soils and a known depth to groundwater of less than 60 feet. Areas that may be affected by a potential liquefaction hazard were also identified and mapped as part of the preparation of this Safety Element. Potential liquefaction hazard areas are identified on Figure 9 as having a high, moderate and low potential for liquefaction to occur. Areas of the City identified by the Safety Element as having a high liquefaction potential include those areas with non-cohesive granular soils and where groundwater is shallowest. Areas of the City with the highest liquefaction risk generally include the following neighborhoods: East Beach, the southern portion of the Eastside, Milpas, Lower East, Lower State, the western portion of Downtown, the southern portion of Laguna, Lower West, the eastern portion of West Beach, the southern portion of the Westside, areas along Arroyo Burro Creek in the Campanil, the Waterfront and Airport.

As indicated in the Description of the Hazard section above, groundwater levels are an important component in determining the potential for liquefaction to occur, and seasonal and long-term variations in groundwater levels can substantially increase or decrease liquefaction hazard risk. To more accurately assess the potential for local groundwater conditions to contribute to liquefaction-related risks in the City, the Safety Element liquefaction hazard risk evaluation included a review of historic groundwater levels throughout the City. This evaluation was conducted by reviewing various geotechnical investigations and reviewing shallow aquifer groundwater level records for various sites in the City that have been monitored for several years or more (*e.g.*, properties with contaminated groundwater assessment/cleanup activities). Additional information regarding groundwater levels in the City is provided in the High Groundwater Hazard section provided below. The liquefaction hazard evaluation was also made using data from various site specific geotechnical studies that collected soil grain size and cohesion data from subsurface exploration to evaluate future site settlement under seismic loading conditions.

As part of the 2011 Santa Barbara Annex to the *Multi-Jurisdictional Hazard Mitigation Plan,* a vulnerability assessment was conducted to identify City-owned facilities that could be adversely affected by hazards, including earthquake-induced liquefaction. The facilities included in the assessment consisted mostly of utility, government, public safety and other infrastructure structures. The vulnerability assessment identified 38 individual structures or buildings located in areas with a "high" potential to experience liquefaction. Most of the identified facilities are located at the Harbor or beach area, the Airport, the City's desalinization facility and the wastewater treatment plant. An additional 28 facilities were identified as being located in an area with a "moderate" potential to experience liquefaction. Please refer to the Santa Barbara Annex for additional information regarding the possible effects of liquefaction on the City's infrastructure and government facilities.

Hazard Reduction

The *Geology and Geohazards Technical Report* provides recommendations regarding the evaluation of potential liquefaction hazards and indicates the types of site investigations to be conducted for various types of development projects proposed within areas identified as having a "high," "moderate," or "low" liquefaction hazard. These recommendations are also applicable to the liquefaction risk zones identified by the Safety Element evaluation of liquefaction hazards in the City. The *Technical Report* hazard reduction guidelines are summarized below. Please refer to the *Geology and Geohazards Technical Report* for a complete description of the recommended hazard evaluation and study requirements.

For areas designated as having a "low" liquefaction hazard potential, the *Geology and Geohazards Technical Report* indicates that no site-specific liquefaction hazard evaluation is required for the construction of minor improvements to existing uses or for new residential buildings. Site investigations should be conducted for commercial, industrial, large public facilities and essential facilities. In areas with a "moderate" liquefaction hazard, screening level site investigations possibly followed by subsurface investigations to assess potential liquefaction hazards should be conducted for all proposed structures. In areas with a "high" liquefaction potential, the *Technical Report* recommends conducting site investigations for minor improvements to existing uses, single family residences multiple residence projects, commercial/industrial projects and essential facilities. Requirements for conducting site-specific liquefaction evaluations are provided by the California Building Code and California Geological Survey Special Publication 117A, *Guidelines for Evaluation and Mitigating Seismic Hazards in California.* Hazard evaluation and mitigation guidelines specified by Special Publication 117A implement the requirements of the Seismic Hazards Mapping Act, but may also be applied to projects located outside of designated hazard zones.

Potential Liquefaction Hazard Zones

Liquefaction is a mitigable hazard and its effects on structures can be minimized through a variety of project site modifications and/or building designs. Site modifications may include compacting soils that have the potential to liquefy, or installing subsurface drains to reduce the potential for groundwater saturation of the soil. Building design measures may include providing building foundations that can withstand expected amounts of liquefaction-induced ground settlement, or constructing buildings on piles that extend to firm soil.

TSUNAMI

Description of the Hazard

A tsunami (also commonly referred to as a seismic sea wave or tidal wave) is a series of waves generated by a vertical displacement of the ocean floor, most commonly as a result of earthquake-related faulting. A tsunami may also be caused by a large undersea landslide or volcanic eruption, or even a meteor impact. In the open ocean, tsunami waves have a wavelength (the distance from the crest of one wave to the crest of the next wave) that may be approximately 100 mile long, a low wave amplitude (the height from the wave crest to trough), and travel at speeds of up to 600 miles an hour. As the waves enter shallow water along the coast, they slow down and the wave height increases. The arrival of tsunami wave crest is often preceded by a trough or recession of sea level. The waves may rise to several feet in height, although in rare cases, may reach heights of tens of feet. The height of the waves will be influenced by many factors, including near-shore bathymetry, shape of the coastline and tide height. After the arrival of the first wave, subsequent waves may increase in height and arrive minutes to hours later.

The effects of a tsunami may be relatively minor, such as flooding of low-lying coastal areas similar to the effects of a rapidly rising tide. Large tsunamis, however, can come onshore as a vertical wall of turbulent water, travel 1,000's of feet inland and cause extensive damage. Damage from large tsunamis can result from inundation, wave impact on structures, debris carried by the wave, and erosion. Tsunamis can also result in the creation of strong and unusual ocean currents.

A tsunami may be generated by local source, such as a nearby fault. When this occurs, the first waves may reach coastal areas within minutes after the groundshaking stops, which limits the ability to issue warnings to potentially affected areas. Tsunamis may also be generated by a distant source, such as large earthquakes that occur in the seismically active Pacific Rim area. Tsunami waves can travel 100's or 1,000's of miles and still maintain enough energy to be destructive when they reach shore.

The West Coast/Alaska Tsunami Warning Center is operated by the National Oceanic and Atmospheric Administration (NOAA) and provides tsunami detection, forecast and warning services for the west coast of the United States. Based on seismic analysis of large earthquakes, sea level data, forecast models, historic data and other criteria, NOAA issues various levels of tsunami warnings. A **tsunami warning** is issued when a tsunami with the potential to generate widespread inundation is imminent, expected or occurring. A **tsunami advisory** is issued there is a potential for tsunami-generated strong currents, or waves that could be dangerous in areas very near the coastline. A **tsunami watch** is issued to alert emergency management officials and the public of an event that may later impact the watch area. A tsunami **information statement** is issued to inform emergency management officials and the public that an earthquake has occurred, or that a tsunami warning, watch or advisory has been issued for another region.

Local Conditions

The threat of a locally-generated tsunami affecting Santa Barbara is relatively low based on the low recurrence interval for this hazard, as large, locally-generated tsunamis in California are estimated to occur about once every 100 years. Reports of past tsunami events in the Santa Barbra area are often poorly documented, such as the accounts of a tsunami that was reported to have occurred on December 21, 1812. Unconfirmed estimates of wave height from this event indicate that a 30- to 35-foot wave occurred in Santa Barbara, but recent studies concluded that the wave was probably 15- to 20-feet at the most. Reported wave heights from other locally-generated tsunami events have generally ranged from less than one foot to about 2.5 feet.

Tsunamis with the potential to adversely affect Santa Barbara can also be generated by distant sources, and two such events have occurred recently. Tsunami waves occurred in Santa Barbara in response to an 8.8 magnitude earthquake off the coast of Chile on February 27, 2010; and the 9.0 magnitude Tohoku, Japan earthquake on March 11, 2011. Additional information about the effects of these events in Santa Barbara is provided on Figure 10.

To assist local jurisdictions with tsunami hazard evacuation planning efforts, a map depicting areas of the City that could be affected by tsunami wave inundation has been prepared by the University of Southern California Tsunami Research Center (Figure 11). Potential inundation areas were identified by evaluating local bathymetry and local and distant sources that could generate a tsunami. Potential tsunami generation sources include movement along local and distant faults, and large undersea landslides in the Santa Barbara Channel. Potential inundation areas were identified based on computer modeling of multiple sources and were adjusted for high tide conditions. Potentially affected areas are low-lying parts of the City generally located south of the U.S. 101 freeway in the East Beach, Waterfront and West Beach neighborhoods. Additional inundation areas were identified near the intersection of Cliff Drive and Las Positas Road in the western end of the West Mesa neighborhood, and at the Santa Barbara Airport.

Tsunamis are most often generated by large earthquakes. There is presently no correlation between the effects of climate change and the reoccurrence interval of tsunami events. However, an accelerated increase in sea level induced by climate change could increase the potential for tsunami-related damage because an increase in sea level could allow waves to travel further inland.

The 2011 Santa Barbara Annex to the *Multi-Jurisdictional Hazard Mitigation Plan* provides a vulnerability assessment to identify City-owned facilities that could be adversely affected by a tsunami. The vulnerability assessment identified 36 individual structures or buildings located in areas that could be affected by tsunami inundation. The identified facilities are located at the Harbor, Airport, the City's desalinization facility and wastewater treatment plant.

Figure 10

RECENT TSUNAMI EVENTS IN SANTA BARBARA

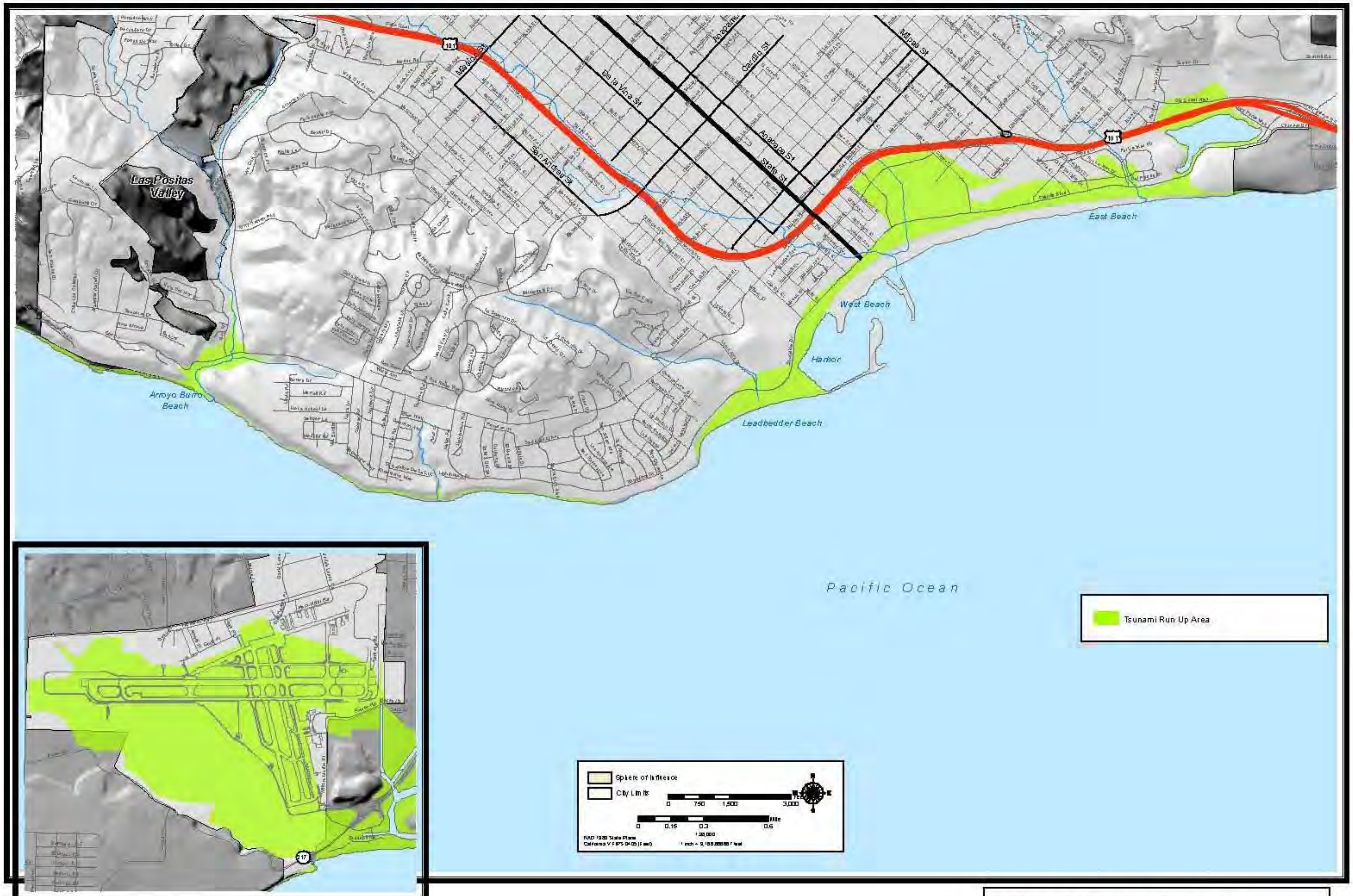
Tsunami waves are often preceded by the retreat of ocean water along the coast. This picture shows the drop in water levels at the Santa Barbara Harbor before waves generated by the 2011 Japan earthquake arrived.

This picture also shows the drop in water level within the Harbor before the arrival of tsunami waves generated by the 2011 Japan earthquake.

As a result of the March 11, 2011 magnitude 9.0 earthquake off the coast of Japan, the West Coast/Alaska Tsunami Center issued a tsunami advisory for the California coast, and tsunami waves occurred in Santa Barbara about 11 hours after the earthquake occurred. Wave run up in the Harbor was about three feet in height, and the waves damaged a crane, bait barge and several boats. Total damage caused by the tsunami waves was estimated to be about $70,000.

On February 27, 2010, a magnitude 8.8 earthquake occurred along the central coast of Chile and a tsunami advisory was issued for California. Tsunami waves of about three feet in height were reported by tide gauges in the Santa Barbra Channel. In Santa Barbara, tsunami waves resulted beach erosion and the displacement of buoys. Tsunami wave surges from this event lasted more than 20 hours.

Photo source: www.sbwatertaxi.com



City of Santa Barbara
General Plan
Tsunami Hazard Zone

Figure 11

Hazard Reduction

Numerous programs have been implemented at the federal, state and local level to identify tsunami-related hazards, reduce the risk of injury and damage caused by tsunamis, and to educate the public about tsunami-related hazards. Federal programs include those implemented under the National Tsunami Hazard Mitigation Program, the United States Geological Survey and NOAA. Hazard reduction programs have been implemented at the State level by the California Geological Survey and Emergency Management Agency. At the local level, tsunami hazards have been evaluated by the *Santa Barbara County Multi-Jurisdiction Hazard Mitigation Plan,* and the *Tsunami Response Plan (2012)* prepared by the City of Santa Barbara Fire Department Office of Emergency Services.

Santa Barbara was designated as a TsunamiReady™ community in 2012, which is a tsunami hazard planning and response program administered by NOAA through the National Weather Service. To be recognized as TsunamiReady, communities must implement specified criteria, including the establishment of a 24-hour warning system, have more than one method to receive tsunami warnings and to alert the public, promote public readiness, and develop a tsunami response plan. The TsunamReady designation is effective for three years and may help to lower the City's National Flood Insurance Program insurance premiums. As part of effort to be designated a TsunamiReady community, the City has installed signs identifying areas that could be inundated by a tsunami and signs that identify designated evacuation routes. Additional information regarding the information signs and designated evacuation routes is provided on Figure 12.

The City's *Tsunami Response Plan* provides information and guidance regarding actions to be implemented upon receiving information that a tsunami watch, advisory or warning is in effect. The Plan addresses a variety of tsunami hazard response actions, including the coordination of evacuation and rescue operations; procedures to allow re-entry into affected or potentially affected areas; and the roles and responsibilities of various City personnel before, during and after a tsunami warning has been issued.

SEICHE

Description of the Hazard

A seiche (pronounced saysh) is a wave or series of waves in an enclosed or semi-enclosed body of water such as a lake, reservoir, harbor or even a swimming pool. Seiche waves can be generated by events such as earthquake-related groundshaking, a landslide into the water body, wind or a tsunami. A wave within the enclosed water body will travel the length of the basin and can be reflected back in the opposite direction. Repeated wave reflections can produce a standing wave in the water body. If the seiche wave overtops the edge of the water body, the wave can run up onto adjacent land areas. The intensity of damage that may be caused by a seiche is proportional to the magnitude and proximity of the event causing the seiche, the amount of freeboard[4] present in the affected water body when the seiche occurs, the size of the water body, and the proximity of development to the edge of the water.

[4] Freeboard refers to the space between the water surface and the top of a structure that contains the water.

Figure 12

TsunamiReady™ DESIGNATED EVACUATION ROUTES

To help educate the public and reduce risks associated with tsunami-related hazards, the City has been designated a TsunamiReady community by the National Weather Service. As part of this effort, the City has prepared a *Tsunami Response Plan,* which outlines procedures and requirements for responding to tsunami hazard warnings issued by the West Coast/Alaska Tsunami Warning Center. As part of the TsunamiReady planning effort, the City has installed signs identifying potential tsunami inundations areas, and signs that identify tsunami hazard zone evacuation routes that have been identified by the *Tsunami Response Plan*.

The following roadways have been designated as evacuation routes and would provide one-way traffic out of potential inundation areas with one lane open for first responders:

- Castillo Street
- Garden Street
- Calle Cesar Chavez
- Milpas Street
- Cabrillo Blvd. west to La Marina
- Cabrillo Blvd. east to Hot Springs Road

Warning signs that have been posted in areas of the City that could be affected by a tsunami wave.

Local Conditions

There are several water bodies in or adjacent to the City that could be affected by a seiche, including the Andre Clark Bird Refuge, Lauro Reservoir and the Harbor. The Andre Clark Bird Refuge is a relatively small and shallow water body and does not present a serious seiche risk. The Lauro Reservoir is located north of and adjacent to the city limits. Should a seiche wave overtop the dam, areas in the City below and in the vicinity of the dam could be inundated. A seiche in the Harbor could cause damage to boats, wharfs and structures adjacent to the water.

Hazard Reduction

Property owners down-hill or adjacent to water bodies that could be affected by a seiche should be made aware of the potential hazard. The 2011 *Santa Barbara County Multi-Hazard Mitigation Plan* indicates that development located adjacent to the Harbor and Lauro Reservoir should consider the possible effects of this hazard. Providing appropriate setbacks between structures and areas that could experience seiche-related inundation would substantially reduce the risk of damage from this hazard.

LANDSLIDES

Description of the Hazard

Landslides occur on sloping ground when the weight of the material that comprises the slope and the weight of objects placed on the slope (driving forces) exceed the shear strength of the slope material (resisting forces). The stability of a slope, or the potential for slope movement to occur, is dependent on many factors, including: the height and steepness of the slope, the shear strength of rock and/or soil that comprises the slope, the orientation of bedding planes in underlying geologic formations, and the amount of water contained in the slope material. These and many other factors will influence the stability of a slope, but in general, sandy or granular soils and rock units are stronger and less likely to be associated with large-scale landsliding than are soil and rock units composed of fine-grained silt or clay.

The down-slope movement of earth material is part of a continuous process of erosion, however, the stability of a slope can be adversely affected by a wide variety of factors. Changes to the stability of a slope can be caused by erosion of the toe of a slope, placing additional weight on the slope, changes to the slope's configuration by grading, earthquake-related groundshaking, or fires that remove vegetation from the surface of the slope. Adding water to a slope can also result in adverse changes to the slope's stability because the water adds weight to the slope, can reduce the cohesion of soil particles, and can also decrease the strength of a zone of weakness (slip plane) within the slope material. The amount of water applied to a slope can be increased in a variety of ways, but intense rainfall can rapidly add extensive quantities of water to slope material. Other possible sources of additional water include irrigation, septic systems, changes in drainage patterns, or broken water/sewer lines.

The down-slope movement of earth material can occur in a variety of ways and the manner in which slope movement occurs will be controlled by the geologic characteristics of the affected area. A **rock slide** involves the movement of bedrock material and typically occurs on steep slopes. An **earth flow** usually occurs in fine-grained (silt and clay) materials and is often initiated by prolonged periods of rainfall. These types of landslides are generally slow moving and may continue to move for days or weeks after movement begins. A **debris slide** typically occurs on steep slopes with coarse-grained soil, usually in response to intense rain events. Debris slides often form steep, un-vegetated scars that are likely to remain un-vegetated for many years. Slopes burned by wildfires are especially susceptible to debris flows due the absence of vegetation and roots to bind surface soils. A **rock fall** is a landslide where a mass of rock detaches from a steep slope. Rock falls generally occur on steep slopes of hard, fractured rock.

Local Conditions

The potential for landslides to affect Santa Barbara and adjacent areas was evaluated by the *Geology and Geohazards Technical Report*, and that hazard assessment identified landslide-prone areas based on the results of previous landslide identification and mapping efforts. The Slope Failure Hazard Zones map provided on Figure 13 depicts four different landslide risk categories identified by the *Technical Report*, ranging from "Very Low" to "High." A summary describing each of the four hazard risk areas is provided below. Please refer to the *Geology and Geohazards Technical Report* for a complete description of the designated landslide risk areas.

Hazard Area 1 – Very Low Landslide Potential

Landslides are very rare to non-existent in these relatively level areas, and areas with this designation will probably remain relatively stable unless the topography is substantially altered. Parts of the City with a Hazard Area 1 designation include the eastern Downtown area, most of the Waterfront, most of the Westside, and the southern part of the Eastside area.

Hazard Area 2 – Low Landslide Potential

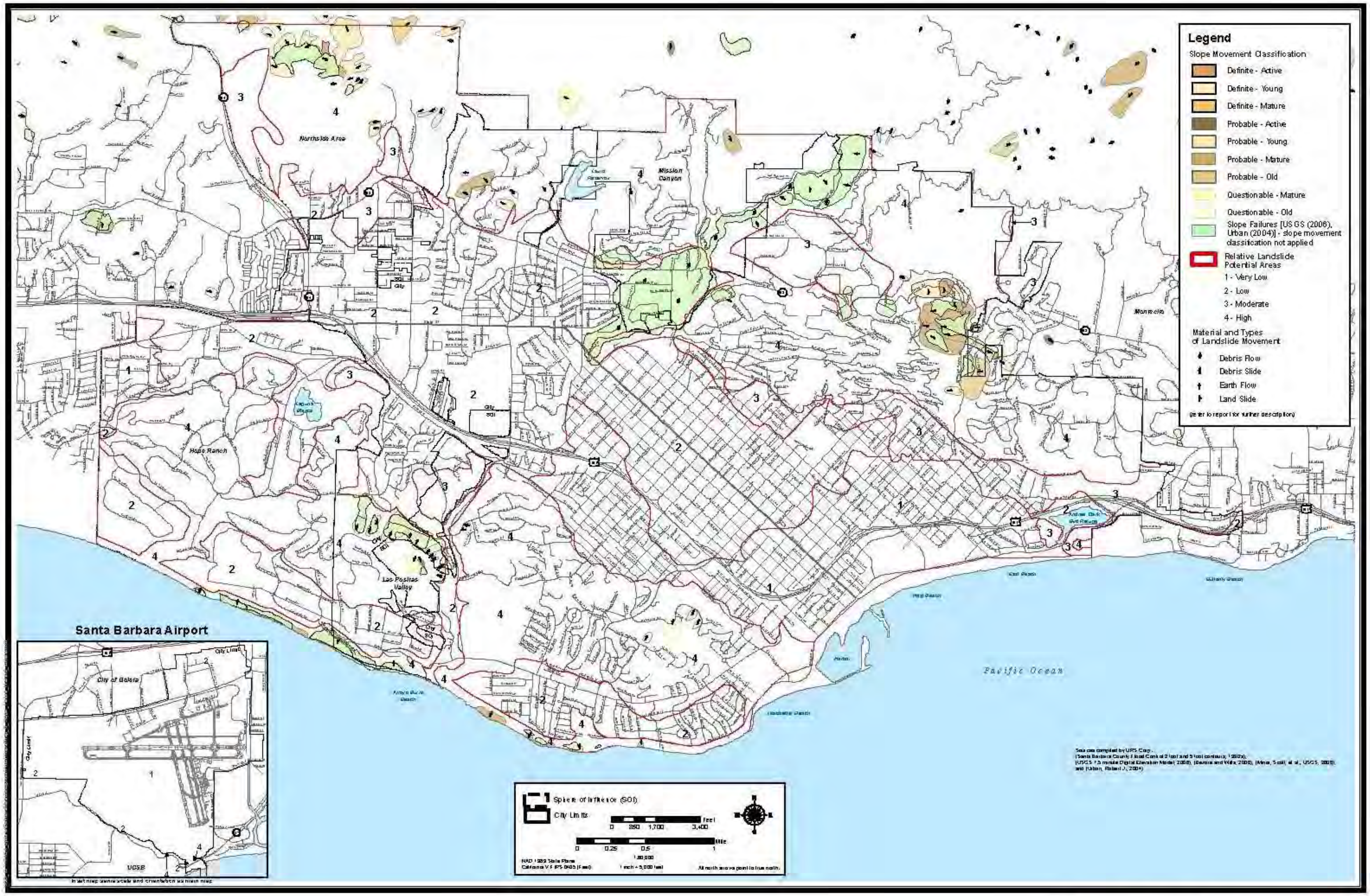
Areas with this designation have gentle to moderate slopes underlain by relatively competent earth material that is considered unlikely to become unstable under natural conditions. The stability of slopes in Hazard Area 2 could change in response to terrain modifications. Hazard Area 2 includes the western part of the Downtown area, southern portions of the Mesa, most of the Upper State area, areas generally adjacent to Las Positas Road and the southern portion of the of the Las Positas area.

Hazard Area 3 – Moderate Landslide Potential

Slopes with this designation are at or near their stability limits due to the presence of weaker geologic materials, steeper slopes, or a combination of these factors. Although most slopes within Hazard Area 3 do not currently contain landslide deposits, the materials that underlie the slopes have the potential to fail if modified. Areas designated as Hazard Area 3 include the northern portion of the Eastside area, the southernmost extent of the Riviera, localized portions of the Riviera, and the northern part of the Las Positas area.

Hazard Area 4 – High Landslide Potential

Slopes in Hazard Area 4 are considered to be naturally unstable and subject to failure even without being modified by grading- or other development-related processes. These areas are characterized by steep slopes and include most areas previously affected by landslides, as well as areas where there is substantial evidence of downward "creep" of surface materials. Soil "creep" is the slow downward movement of surface soil that typically occurs in clay-rich, expansive soils that expand when wet and contract when dry. Earthflows are the most common type of slope failure in these hazard areas, but slides of intact bedrock are also common. Hazard Area 4 includes parts of the Mesa north of SR 225, the steep slopes located along the west side of the Las Positas area, most of the Riviera, and the coastal bluffs in the southwestern part of the City. Additional information about coastal bluff erosion hazards is provided in the Sea Cliff Retreat section of the Safety Element.



City of Santa Barbara
General Plan
Slope Failure
Hazard Zones

Figure 13

Two areas of recent landsliding are located in Sycamore Canyon and are commonly referred to as the "Conejo Road Landslide" and the "Canon View Road/Sycamore Canyon Landslide." Movement of slopes in this area apparently began in response to heavy "El Niño" rain events in 1982-83. In January 2005 heavy rains resulted in additional slope movement that resulted in the closure of a two-mile segment of State Route 144 (Sycamore Canyon Road) south of State Route 192. In addition to closing the highway, eight homes were destroyed and many other homes, roadways and driveways experienced structural damage. The damaged section of SR 144 was gated and closed, and could only be opened when a high fire danger "Red Flag Alert" was in effect. In the Canon View Road area, using a 50 million dollar settlement agreement from Caltrans, affected property owners formed a corporation that was responsible for repairing, restoring and stabilizing the landslide on the east side of Sycamore Canyon. The landslide repair project was initiated in 2007 and implemented extensive engineering and construction methods to remediate the slide, including the use of retaining walls, numerous reinforced concrete piers, structures to tie the piers together and anchor them to the hillside, reinforced earthfills and buttresses, and new drainage systems. The landslide remediation project required five years to complete and SR 144 was opened to motorists and emergency vehicles on April 3, 2012.

The Conejo Road and Sycamore Canyon landslides clearly demonstrate the damage that can be caused by local landslides and the resources that may be required to repair landslide-related damage. Other recent landslide events have demonstrated that the Santa Barbara area can be adversely affected even when a landslide occurs well beyond the city limits. In January 2005 a series of strong storms triggered a large debris flow above the community of La Conchita in Ventura County, and the landslide resulted in 10 deaths and damaged or destroyed 36 residences. Debris from the landslide extended across U.S. Highway 101, which resulted in the closure of the highway and constrained access to Santa Barbara from the south while the debris was removed.

As part of the Santa Barbara Annex to the *Multi-Jurisdictional Hazard Mitigation Plan,* a vulnerability assessment was conducted to identify City-owned utility, government, public safety and infrastructure facilities that could be adversely affected by landslide-related hazards. The vulnerability assessment concluded that no "critical" City-owned facilities were located in areas designated as having a "high" or "moderate" landslide risk.

Hazard Reduction

The *Geology and Geohazards Technical Report* indicates when site-specific slope stability investigations should be prepared for various types of development projects based on the project's location and the landslide risk designation depicted on Figure 13. The *Technical Report* landslide hazard evaluation guidelines are summarized below. Please refer to the *Geology and Geohazards Technical Report* for a complete description of the recommended hazard evaluation and study requirements.

If a project site is located outside a designated hazard area or is located within Hazard Areas 1 or 2, a slope stability geotechnical evaluation will not be required for most types of projects unless the project could result in a slope stability hazard due to proposed excavations or the creation of fill slopes. A site-specific geotechnical analysis that considers the potential for landslide-related impacts is recommended for essential/critical facilities located in Hazard Areas 1 or 2. With possibly a few exceptions for very minor projects, a site-specific geotechnical report to evaluate potential slope stability hazards should be required all development projects located within or adjacent to Hazard Areas 3 or 4.

The objective of required slope stability investigations is to evaluate existing slope stability conditions and to determine if project-related modifications to a slope would have the potential to result in on- or off-site stability impacts. If necessary, the evaluation should also identify ways that the project and/or that proposed changes to a slope can be modified to minimize stability-related impacts. Numerous methods can be used to evaluate the stability of a particular slope, but in general slope stability evaluations estimate the strength of the soil or rock that comprise the slope (resisting forces), and the weight of the slope and objects placed on the slope (driving forces) above a potential slide surface or "slip plane." The value of the resisting forces divided by the value of the driving forces to determine a "factor of safety." A value below 1.0 is theoretically impossible because the slope would have already failed. A value of 1.0 indicates marginal stability/a failure is imminent. As values increase above 1.0, confidence that the slope is stable also increases. A factor of safety of 1.5 (and a factor of safety of 1.1 under seismic shaking conditions) is typically required to demonstrate that a slope would remain stable after the implementation of a proposed project. Typically, many potential sliding surfaces will be evaluated and the surface with the lowest factor of safety will be the location where slope failure is most likely to occur. Slope stability geotechnical evaluations prepared pursuant to the *Geology and Geohazards Technical Report* guidelines should be consistent with the geology report preparation guidelines adopted by the California Board for Geologists and Geophysicists. Site-specific studies should also comply with requirements required by the California Building Code and California Geological Survey Special Publication 117, *Guidelines for Analyzing and Mitigating Landslide Hazard in California*.

A variety of techniques may be used to mitigate slope stability hazards, and one or more methods may be recommended by a site-specific slope stability evaluation. Common methods for minimizing landslide-related hazards may include avoidance of hazardous areas, removal of unstable material, appropriately engineered grading prior to construction, dewatering slopes and controlling site drainage, reducing the slope gradient or the weight of objects placed on the slope, and the use of drought tolerant landscaping with strong root systems. Geotechnical engineering design measures, such as those used in the Conejo Landslide area, may also be used to reduce landslide hazards in areas that have been previously developed.

The Santa Barbara Annex to the *Multi-Jurisdictional Hazard Mitigation Plan* includes recommended mitigation actions to reduce landslide-related risks to City-owned facilities or on City-owned property. The recommended mitigation actions include the stabilization of hillsides in Honda Valley in the Alta Mesa neighborhood that are located adjacent to a high pressure gas line that serves the City; slope stability improvements along steep creek banks in Hidden Valley Park in the Hidden Valley neighborhood; improvements to address slope undercutting that could contribute to a landslide and adversely affect vehicle and emergency access to Stevens Park in the East San Roque neighborhood; conduct geotechnical studies, stabilize slope retaining walls, and provide drainage improvements in the area of Francheschi Park/Mission Ridge Road to minimize landslide- and resulting access-related impacts; and provide improvements to gravity/unreinforced retaining walls in the high fire hazard zones of the City to reduce the potential for landslide-related access impacts.

SEA CLIFF RETREAT

Description of the Hazard

Sea cliff retreat is an erosion- and landslide-related hazard that affects the ocean bluffs located along the City's coast. The coastal bluff environment is very dynamic and can present great variation in the composition, structure and strength of the rocks and soil that form the bluffs. These conditions result in hazard assessment and reduction challenges not generally associated with natural or manufactured slopes located in inland areas.

Sea cliff retreat is a continual, natural process caused by both marine and terrestrial erosion process that causes the face of the bluff to "retreat," or move landward. Wave action is the predominant erosional process in the Santa Barbara area as waves can erode the base of the cliff and remove support for overlying cliff material, which increases the potential for landslides to occur. Bluffs that are subject to wave-related erosion often have a configuration that is vertical or nearly vertical. Where beaches are wide and waves seldom reach the base of the cliff, terrestrial processes, such as erosion by stormwater runoff over the face of the bluff, can be the dominant cause of sea cliff retreat. Terrestrial erosion processes generally result in the formation of bluffs with a more gently sloping profile.

Ocean bluffs may appear to go unchanged for many years as erosion of the cliff occurs slowly, either by the gradual ("grain-by-grain") loss of bluff material, or by the loss of small blocks or shallow slumps of surficial material. This gradual loss of sea cliff material typically occurs as a result of terrestrial erosion processes. Conversely, extensive losses of bluff material may occur suddenly due to large landslides that occur when the stability of the slope is adversely changed and "driving" forces exceed the "resisting" forces of the bluff material[5]. The addition of water to the bluff during heavy rainfall events is a common trigger for landslides. Although large slope failures occur infrequently, these episodic events and the associated loss of material will substantially influence the overall average rate of bluff retreat.

Rates of sea cliff retreat can be delayed or accelerated by human actions. Seawalls and revetments can slow sea cliff retreat at a specific site, but can also result in increased beach sand erosion and accelerated bluff erosion adjacent to the protective structure. Increases in the amount of water that infiltrates into the bluff by rainfall, irrigation, septic tanks or changes in drainage patterns can increase the rate of cliff erosion by increasing water pressure within the material that comprises the bluff, and by adding weight to the bluff. The application of water to the top of the bluff can also result in water percolating into the bluff and emerging on the bluff face as a spring or seep, which can substantially weaken the cliff. Other actions that can increase the rate of bluff retreat include adding structures (weight) to the top of the bluff, which can increase the potential for landslides; the construction and use of pathways on the cliff face, which can concentrate and accelerate runoff-related erosion; and planting vegetation with shallow roots or that becomes heavy and can pull soil away from the cliff face.

Local Conditions

There are approximately four miles of coastal bluffs within the City limits, including the cliffs that form the southern portion of the West Mesa and East Mesa neighborhoods, and the cliffs adjacent to the Clark Estate and the Santa Barbara Cemetery in the East Beach neighborhood. The height of the sea cliffs in Santa Barbara gradually decrease from west to east, with cliffs of about 150 feet located in the Douglas Family Preserve area; 100 feet in the West Mesa neighborhood; and about 50 feet along Shoreline Park in the East Mesa neighborhood. The coastal bluffs are about 50 feet in height adjacent to the cemetery in the East Beach neighborhood of the City.

Most to the sea cliffs in the City are comprised of Monterey shale that is capped by unconsolidated marine terrace deposits. The shale is often comprised of thin beds that can vary in structure and composition, and that have been folded, fractured and tilted. The potential for slope failure can be substantially increased when bedding planes dip (tilt) toward the beach at an angle that is less steep than the sea cliff face, a condition referred to as "daylighted" bedding.

[5] Please refer to the Landslide section for additional information regarding "driving" forces and "resisting" forces.

Several large landslides have affected the Santa Barbara ocean bluffs in the recent past. On February 14, 1978, the El Camino de la Luz landslide encompassed an area approximately three acres in size and resulted in the destruction of two homes. The eastern edge of the landslide was located approximately 400 feet west of Lighthouse Creek in the East Mesa neighborhood. The probable cause of this landslide was determined to be bedding planes that dipped toward the beach and surface water runoff that permeated the ground in the slide area as a result of a series of large storms. On January 25, 2008, a landslide affected the bluff in Shoreline Park. This landslide extended 70 feet along the top of the cliff and moved the bluff edge landward 38 feet. Other landslide areas along the bluffs adjacent to the East and West Mesa neighborhoods are depicted on Figure 13, Slope Failure Hazard Zones. Overall, the bluffs adjacent to the Mesa neighborhoods and the Santa Barbara Cemetery/Clark Estate have been designated by the *Geology and Geohazards Technical Report* as having a "high" landslide potential.

Sea Cliff Retreat Rates

As described above, sea cliff retreat occurs as a result of a terrestrial and marine erosional processes, can be influenced by human activities and variations in the structure of the bluffs, and can occur slowly due to "grain-by-grain" erosion or rapidly as a result of large landslides. When all of these factors are considered over an extended period of time, an average rate of bluff retreat can be estimated.

Several different studies of sea cliff retreat rates have been conducted in the Santa Barbara area. The *Geology and Geohazards Technical Report* reports that a study by Norris (1986) evaluated coastal erosion rates along the Santa Barbara coastline that occurred over a 70-year period and determined that the highest retreat rate was approximately 12 inches per year, while the average erosion rate was eight inches per year. The difference between the highest and average retreat rates emphasizes that sea cliff retreat does not occur at a steady rate and can be highly variable over time.

The *City of Santa Barbara Sea Level Rise Vulnerability Study* (Griggs, 2012) reports that based on a review of historical aerial photographs, average long-term sea cliff retreat rates in Santa Barbara ranged between six and 12 inches per year. Another study by Hapke and Reid (2007) compared cliff edge positions on aerial photographs from the 1930's with LiDAR[6] data from 1998. That study identified average sea cliff retreat rates of about four to 18 inches per year for cliffs adjacent to the West and East Mesa neighborhoods, and just under six inches per year for the cliffs adjacent to the Clark Estate/Santa Barbara Cemetery in the East Beach neighborhood.

The estimated rates of sea cliff retreat vary due to local differences in the composition and structure of the bluffs, the effects of bluff-top development, and barriers located at the base of the bluffs such as cobbles, boulders, or rip rap. Although there can be a wide variation in the rate of retreat at individual sites and bluff retreat generally occurs in an episodic manner, the average rate of retreat for the Santa Barbara bluffs when measured over an extended period of time is about six to 12 inches per year. At that average rate, the City's ocean bluffs can be expected to retreat by approximately 10-20 feet over the next 20 years, and approximately 45 to 90 feet by 2100.

[6] LiDAR is an acronym for Light Detection and Ranging. This system uses a narrow laser beam to map physical features with very high resolution.

The *Geology and Geohazards Technical Report* identifies areas adjacent to the current (2013) bluff edge that may be affected by sea cliff retreat over the next 75 years. A 75-year timeframe was used because this is the period of time used by the City as the expected design life of new structures, and if sea cliff retreat were to threaten a structure that is at least 75 old, the structure would likely be obsolete and ready for demolition for reasons other than encroaching erosion. Based on a conservative (the highest average bluff retreat rate) estimate of 12 inches of sea cliff retreat per year, for planning purposes it can be expected that the bluff edge that existed in 2012 will retreat landward by approximately 75 feet over the next 75 years (2088). Figure 14, 75-Year Sea Cliff Retreat Line, depicts the bluff-top areas of the City that could be affected by sea cliff retreat over the next 75 years. This figure presents a theoretical bluff retreat area that is to be used for planning purposes only. Actual rates of sea cliff retreat and the area that may be affected over the next 75 years will vary considerably due to site-specific geologic and other conditions.

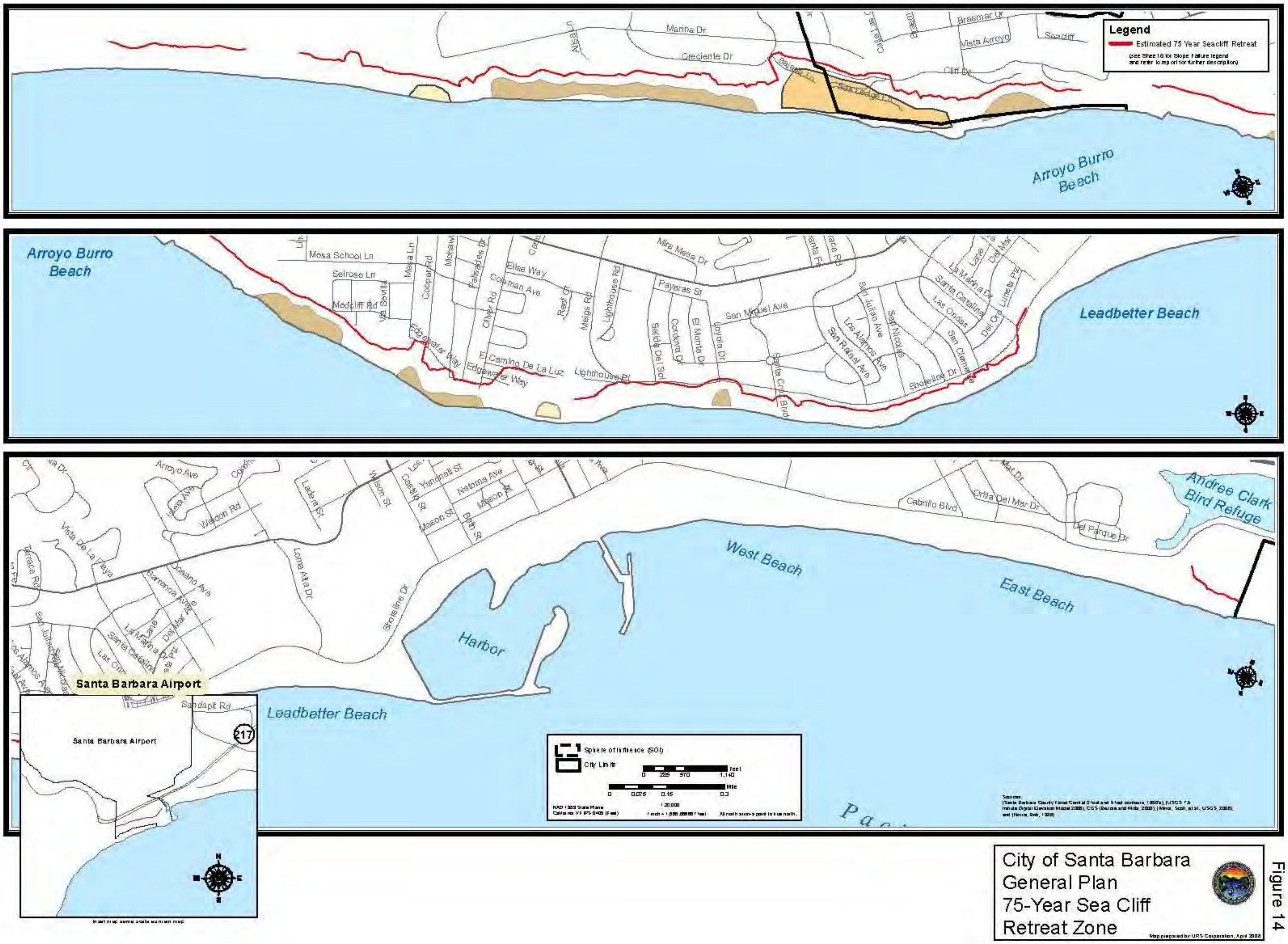
Resources that May be Affected by Sea Cliff Retreat

There are 98 single-family homes in the East and West Mesa neighborhoods located in the vicinity of the ocean bluff edge. Two major City parks, Shoreline Park and the Douglas Family Preserve, as well as the Santa Barbara Cemetery and the Clark Estate, are also located along the edge of an ocean bluff. The single-family residences located adjacent to the bluff edge were constructed at different times and with different setbacks from the bluff's edge, but as of 2012, are setback from the bluff edge by approximately 35 to 300 feet. There are approximately 25 residences located within 75 feet of the existing bluff edge, and facilities in Shoreline Park such as walkways and a restroom structure are within 50 feet of the present cliff edge. Although bluff retreat is episodic and actual rates of retreat over a given period cannot be predicted with certainty, residences, park facilities and associated streets, structures, parking lots, storm drains, water and sewer lines located within 75 feet of the bluff edge will be vulnerable to damage or destruction due to ongoing sea cliff retreat.

Sea Cliff Retreat Rates and the Effects of Climate Change

An expected consequence of climate change caused by increasing concentrations of greenhouse gases in the Earth's atmosphere is a rise in sea level, primarily due to the breakup and melting of ice caps and glaciers and a volumetric expansion of seawater as it warms. As sea level rises, ocean bluffs will be more vulnerable to wave-related erosion, which will likely result in an increase in existing sea cliff retreat rates.

Long-term measurements of sea level elevation along the California coast have indicated that ocean is rising. Of the 12 tide gages maintained along the California coast by the National Oceanic and Atmospheric Administration, 10 of the gages have recorded average sea level rise rates that range between 0.83 and 2.22 mm/yr. Exceptions to these measurements have occurred at Humboldt Bay, where sea level has risen at a rate of 4.72 mm/yr, which indicates that land in the area is subsiding. At Crescent City, measured sea level is dropping 0.65 mm/yr, which indicates that the land surface in that area is being uplifted at a rate that is greater than global sea level rise. Satellite data collected since 1993, which is not influenced by regional effects of land subsidence or uplift, indicate that the average global rate of sea level rise is a little more than three mm/yr. A tide gage at the Santa Barbara Harbor has indicated an average sea level rise of 1.25 mm/year, however, the gage has been relocated twice resulting in a large possible measurement margin of error.


Legend
Estimated 75 Year Seacliff Retreat
Arroyo Burro Beach
Marina Dr
Creciente Dr
Braemar Dr
Vista Arroyo
Seacliff
Cliff Dr
Arroyo Burro Beach
Mesa School Ln
Selrose Ln
Medcliff Rd
Mesa Ln
Cooper Rd
Elise Way
Coleman Ave
Palisades Dr
Oliver Rd
Edgewater Way
El Camino De La Luz
Lighthouse Rd
Lighthouse Pl
Meigs Rd
Mira Mesa Dr
Payeras St
San Miguel Ave
Salida Del Sol
Cordova Dr
El Monte Dr
Loyola Dr
Santa Cruz Blvd
San Julian Ave
Los Alamos Ave
San Rafael Ave
San Nicolas
Santa Catalina
Las Ondas
La Marina Dr
Del Oro
Shoreline Dr
Leadbetter Beach
Arroyo Ave
Weldon Rd
Vista De La Playa
Oceano Ave
Loma Alta Dr
Ladera St
Wilson St
Yanonali St
Natoma Ave
Mason St
Bath St
Shoreline Dr
Harbor
West Beach
East Beach
Cabrillo Blvd
Orilla Del Mar Dr
Del Parque Dr
Andree Clark Bird Refuge
Santa Barbara Airport
Sandspit Rd
217
Leadbetter Beach
Sphere of Influence (SOI)
City Limits
Feet
Mile
Pacific
City of Santa Barbara
General Plan
75-Year Sea Cliff
Retreat Zone
Figure 14

Estimates of future increases in the elevation of sea level vary considerably based on assumptions regarding greenhouse gas emission control effectiveness and other factors. The California Ocean Protection Council, which consists of representatives of 15 state agencies, has adopted future sea level rise projections for use in State planning and regulatory actions. These sea level rise guidelines identify a five- to eight-inch rise in sea levels over year 2000 conditions by 2030; 10-17-inches of sea level rise by 2050; and between 31 and 69 inches of sea level rise by 2100.

Other possible climate change-related effects could also increase existing average sea cliff retreat rates in the Santa Barbara area. For example, changes in climatic conditions may result in an increase in the frequency and severity of storms, and an increase in the height of waves as they approach the shore. Such changes to ocean conditions will result in increased ocean bluff erosion by storm waves.

Although there is substantial variation in predictions of future increases in sea level, particularly for conditions between 2050 and 2100, it is reasonably expected that the combination of increased sea levels and storm severity will lead to increased rates of erosion at the coastline, including a narrowing of beaches and an increase in the frequency and intensity of wave attack at the base of the coastal bluffs. There are locations in the Mesa neighborhoods where terrestrial processes are currently the predominant source of bluff erosion, which has resulted in the creation of cliffs with a rounded appearance. An increase in sea level and wave height will result in a corresponding increase in wave attack at the base of those bluffs, resulting in a steepening of the cliff face and increased retreat rates. At bluff locations along the Mesa where marine process are the predominant form of erosion and the cliffs have a steep gradient, an increase in sea level and wave height will expose the base of the cliff to increased wave attack, which could result in a substantial increase in existing retreat rates.

Similar to the uncertainty associated with predictions of future climate change-induced increases in sea level, there is extensive variation in predictions regarding future increases in the rates at which sea cliff retreat will occur. The *California Climate Adaptation Strategy* (2009) indicates that a recent study of southern California concluded that erosion rates are expected to accelerate by 20 percent for a sea-level rise of 39.4 inches (100 cm). Under such a scenario, the average rate of sea cliff retreat in Santa Barbara would increase from the current six to 12 inches per year to approximately seven to 14 inches per year.

In his assessment of the possible effects of sea level rise in Santa Barbara, Griggs bases his analysis of impacts associated with an increase in sea cliff retreat rates on the assumption that erosion rates will double to approximately 12-24 inches per year. Griggs concludes that there is a “moderate” potential for such an increase in average sea cliff rates to occur over the short- to intermediate-term (2012 to 2050), and a “high” or “very high” probability for such increases over the intermediate- to long-term (2050-2100). If sea cliff retreat rates were to double, Santa Barbara could experience up to 80 to 160 feet of erosion landward of the present cliff edge by the year 2100, which could threaten or require the removal of about 67 bluff top homes in the Mesa neighborhoods.

The *Plan Santa Barbara EIR’s* evaluation of long-term (2050 to 2100) climate change induced changes to existing sea cliff retreat rates indicates that the bluffs along Shoreline Park could retreat by 275 feet from their present location by the year 2100, and cliffs adjacent to residential areas of the Mesa could retreat 525 feet from their present location by 2010. These projections would require average erosion rates to increase by three to six times above current average rates of retreat in the Shoreline Park area, and six to 12 times above current average retreat rates in the Mesa neighborhoods. In his assessment of possible future sea cliff retreat rates, Griggs suggests using these sea cliff retreat rate projections with caution, and recommends that a program to monitor sea cliff retreat rates be established. Documentation of future changes in sea cliff retreat rates will provide the City with information needed to respond appropriately to increased sea cliff retreat hazards.

Hazard Reduction

The California Coastal Act requires that new development shall:

(1) Minimize risks to life and property in areas of high geologic, flood and fire hazard.

(2) Assure stability and structural integrity, and neither create nor contribute significantly to erosion, geologic instability, or destruction of the site or surrounding area or in any way require the construction of protective devices that would substantially alter natural landforms along bluffs and cliffs. (CCR Section 30253)

This law requires that new development be sited in such a way that it will not be subject to erosion or stability hazards during its design life, and that coastal armoring (i.e., seawalls, revetments, etc.) will not be needed to protect the development. As described above, the City assumes a 75-year design life for primary structures, including remodels or additions. Based on an assumed 75-year structure design life, an appropriate setback distance from the existing bluff edge is determined by multiplying the average annual sea cliff retreat rate appropriate for the project site by 75. Proposed accessory structure, patios, landscaping and other minor improvements may be located seaward of the 75-year sea cliff retreat line with discretionary City approval that recognizes that such development may have less than a 75-year design life or can be easily removed if threatened by sea cliff retreat.

The *Geology and Geohazards Technical Report* indicates that a site-specific sea cliff retreat evaluation should be prepared if habitable structures (i.e., single- or multi-family dwellings), commercial/industrial buildings, essential facilities, or minor improvements are proposed to be located seaward of the sea cliff retreat line depicted on Figure 14, or within 50 feet of the bluff edge, whichever is greater. No evaluation report is required for such development if it would be located landward of the sea cliff retreat line provided on Figure 14, or more than 50 feet of the bluff edge, whichever is greater.

The required sea cliff retreat evaluation study should comply with report preparation guidelines identified by the *Geology and Geohazards Technical Report*, and the requirements of the California Coastal Commission as described in a 2003 memorandum and that is provided as Safety Element Technical Background Report Appendix B. In summary, the Coastal Commission memo requires sea cliff retreat evaluations to include several analysis steps, including: determine the location of the bluff edge; evaluate the stability of the bluff at the project site; identify appropriate long-term erosion rates to evaluate sea cliff retreat rates at the project site and to identify a 75-year erosion setback line; and if necessary, identify a structure setback factor of safety.

Development setbacks are typically measured from the existing bluff edge, which is commonly defined as the intersection between the steeply sloping bluff face and the flat or more gently sloping bluff top. However, determining the actual location of the bluff edge can be subject to various interpretations, particularly if the bluff edge is irregular, rounded, there is a sloping bluff top, or previous development has occurred near the bluff edge. Additional guidance regarding the determination of where the bluff edge is located is provided in Appendix B.

After the location of the bluff edge has been determined, the bluff should be evaluated to determine if it is stable (i.e., not subject to landslide failure under various, static or earthquake conditions, or due to increases in groundwater levels due to storm conditions). If the bluff is determined to be stable, and it is also determined that it would remain stable after the completion of the proposed development, then an appropriate setback from the bluff edge to the proposed structure(s) that will accommodate at least 75 years of sea cliff retreat plus a factor of safety is identified. Sea cliff retreat rates used to determine the structure setback distance should consider site-specific historic rates of erosion, as well as future rates of erosion that may occur as a result of changing climatic conditions. If it is determined that the bluff is not stable, the distance from the unstable bluff edge to a position on the project site where the bluff is considered to be stable must be identified. From the location where the bluff is considered to be stable, a 75-year erosion setback is then established. This setback distance should also consider historic sea cliff retreat rates as well as possible future increases in retreat rates. Additional information regarding the evaluation of sea cliff stability and the identification of historic sea cliff retreat rates is provided in Appendix B and by the *Geology and Geohazards Technical Report*.

A variety of measures may be implemented to minimize the potential effects of sea cliff retreat/slope stability impacts on new development. While specific measures should be identified by a site-specific evaluation, general measures include controlling site drainage to minimize the infiltration of stormwater into subsurface materials, minimizing the application of landscape water, and avoiding the use of septic systems. Structure foundations and design elements should extend to suitable depths, and be of appropriate strength to not be compromised and to support the structure in the event of bluff failure or if retreat encroaches upon the foundation of the structure.

The Santa Barbara Annex to the *Multi-Jurisdictional Hazard Mitigation Plan* includes recommended mitigation actions to reduce the effects of sea cliff retreat on City-owned facilities. The recommended mitigation actions include continued management of sidewalks, vegetation and other facilities in Shoreline Park; rebuilding the beach access steps known as “1000 Steps” located west of Shoreline Park in the Mesa East neighborhood; and maintenance of the Mesa Lane coastal access steps in the West Mesa neighborhood.

SOIL EROSION

Description of the Hazard

Soil erosion occurs when wind, water or ground disturbances cause soil particles to move and be deposited elsewhere. Numerous conditions will influence the susceptibility of soil to the effects of erosion, although the characteristics of the soil, vegetative cover and topography are important factors. Soils with a high clay content are generally less susceptible to erosion than soils with a high sand or silt content. Soils with a high organic material content are often less susceptible to erosion because the organic matter helps to bind the soil particles, and also absorbs water which reduces runoff. Soils that are compacted will promote higher water runoff rates, which can increase erosion. Soils covered with vegetation are less susceptible to erosion because the plants add organic material to the soil, shelter the soil from wind, and the plant roots bind the soil together. The removal of vegetation by construction activities or wildfire can result in a substantial increase in erosion rates. Areas with steep topography are more susceptible to erosion because sloping areas will generally have higher runoff water velocities, which increase the ability of water to dislodge and carry soil particles.

Increases in soil erosion rates caused by disturbances of the ground surface, fires or other causes can result in increased sediment loads in receiving waters such as ponds, reservoirs, streams and the ocean. Increased sediment loads can have a variety of adverse effects on water quality. In addition to impacts such as decreased water clarity, reduced light penetration and diminished photosynthesis in aquatic plants, sediment particles can carry pollutants such as nutrients, bacteria, pesticides, metals and hydrocarbons. These pollutants can impair water quality by promoting algae growth and associated decreases in dissolved oxygen levels, and may also be toxic to aquatic organisms.

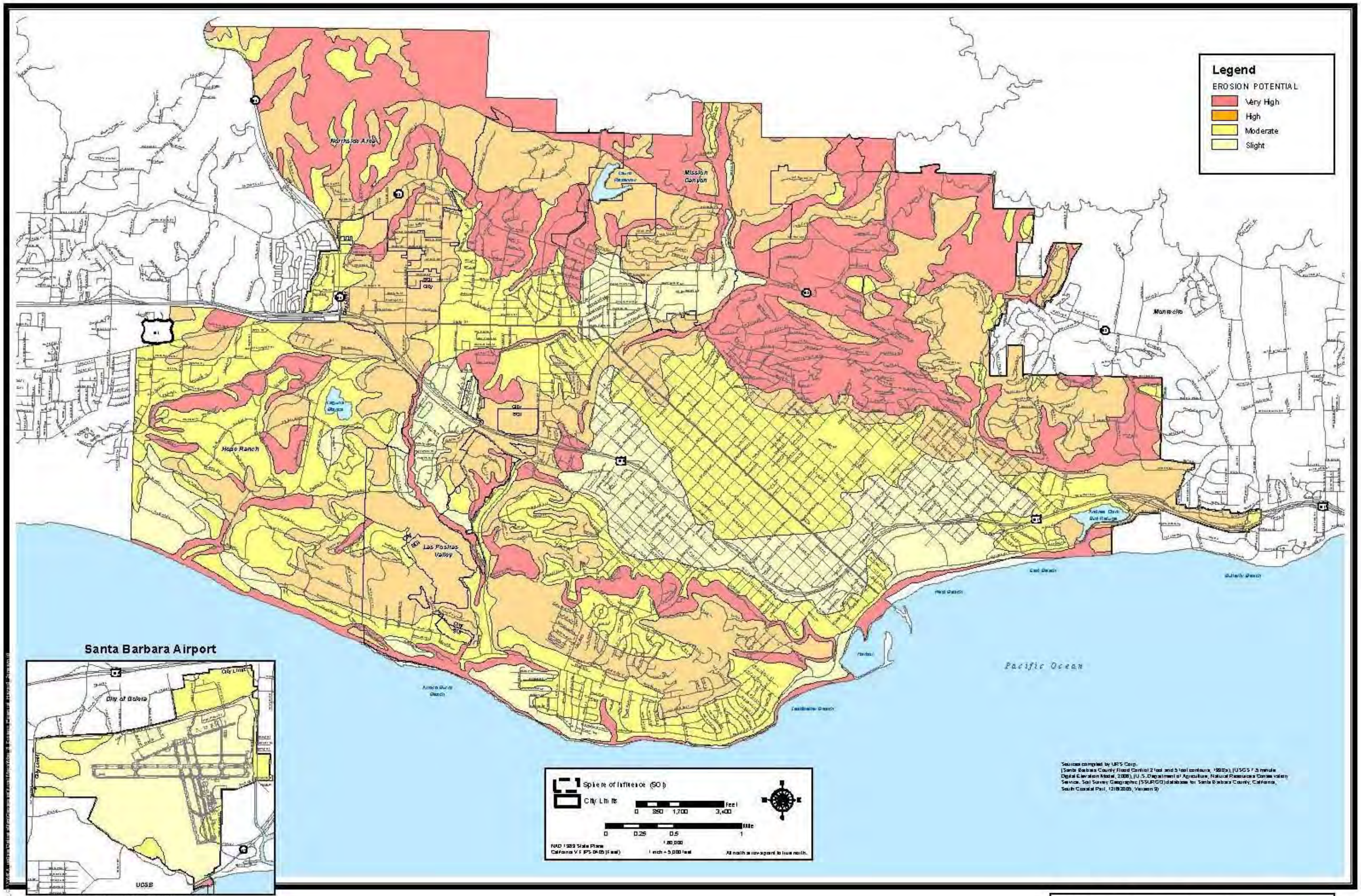
Local Conditions

Potential erosion hazards areas in the City were identified by the *Geology and Geohazards Technical Report* based on soil characteristic data obtained from the U.S. Department of Agriculture – National Resource Conservation Service. Erosion hazard levels throughout the City were classified on a scale ranging from "Very High" to "Slight," and are depicted on Figure 15, Erosion Potential Hazard Zones. In general, areas with a higher erosion hazard potential are located in the hillside or sloping areas of the City, such as the Riviera, and portions of the Upper State, Mesa and Las Positas areas. Portions of the City that are level or with only moderate slopes are generally classified as having a "Moderate" to "Slight" erosion hazard potential.

Hazard Reduction

Numerous federal, state and local regulatory programs have been enacted to reduce the potential for erosion-related hazards. At the federal level, the Clean Water Act and National Pollutant Discharge Elimination System (NPDES) permits require the implementation best management practices to reduce erosion and sedimentation from non-point sources such as construction sites. In 1990, California implemented the Porter-Cologne Water Quality Control Act, which enables the State Water Resources Control Board to implement federal NPDES requirements. Federal and State regulations are also implemented at the local level by programs such as the Santa Barbara Storm Water Management Program, which provides policies and programs for managing storm water runoff from development sites; the Storm Water Best Management Practices Guidance Manual, which provides information related to the implementation of erosion control best management and low impact development practices; and the building and grading requirements provided by Title 22, Environmental Policy and Construction, of the City's Municipal Code.

The *Geology and Geohazards Technical Report* provides recommendations regarding the evaluation of potential erosion hazards at development project sites. The *Technical Report* indicates that a site-specific erosion potential investigation is not required for projects located in areas designated as having a "Slight" erosion potential. In areas designated as having a "Moderate" erosion potential, a site investigation should be required for projects that would result in the creation of steep fill slopes. With some exceptions for very minor projects, site-specific erosion investigations should be prepared for all proposed development projects in areas with a "High" or "Very High" hazard classification. The *Geology and Geohazards Technical Report* also describes the type of information that should be included in a project-specific erosion evaluation. In general, the assessment is to be consistent with federal, state and local regulatory requirements and should identify feasible methods to control erosion during and after the completion of construction activities. Please refer to the *Geology and Geohazards Technical Report* for a complete description of the recommended erosion hazard evaluation and study requirements.



City of Santa Barbara
General Plan
Erosion Potential
Hazard Zones

Figure 15

EXPANSIVE SOIL

Description of the Hazard

Expansive soils, also known as "shrink/swell" soils, will expand when wet and shrink when they become dry. The expansion of the soil occurs when clay minerals contained in the soil attract and absorb water. Water that causes the soil to swell may be derived from precipitation, irrigation, or other moisture sources. Repeated cycles of shrinking and swelling can cause building foundations, walls, ceilings and floors to crack, and windows and doors to warp so that they do not function properly. Differential shrinking and swelling can also damage surface improvements such as roadways and sidewalks, often resulting in a "wavy" appearance.

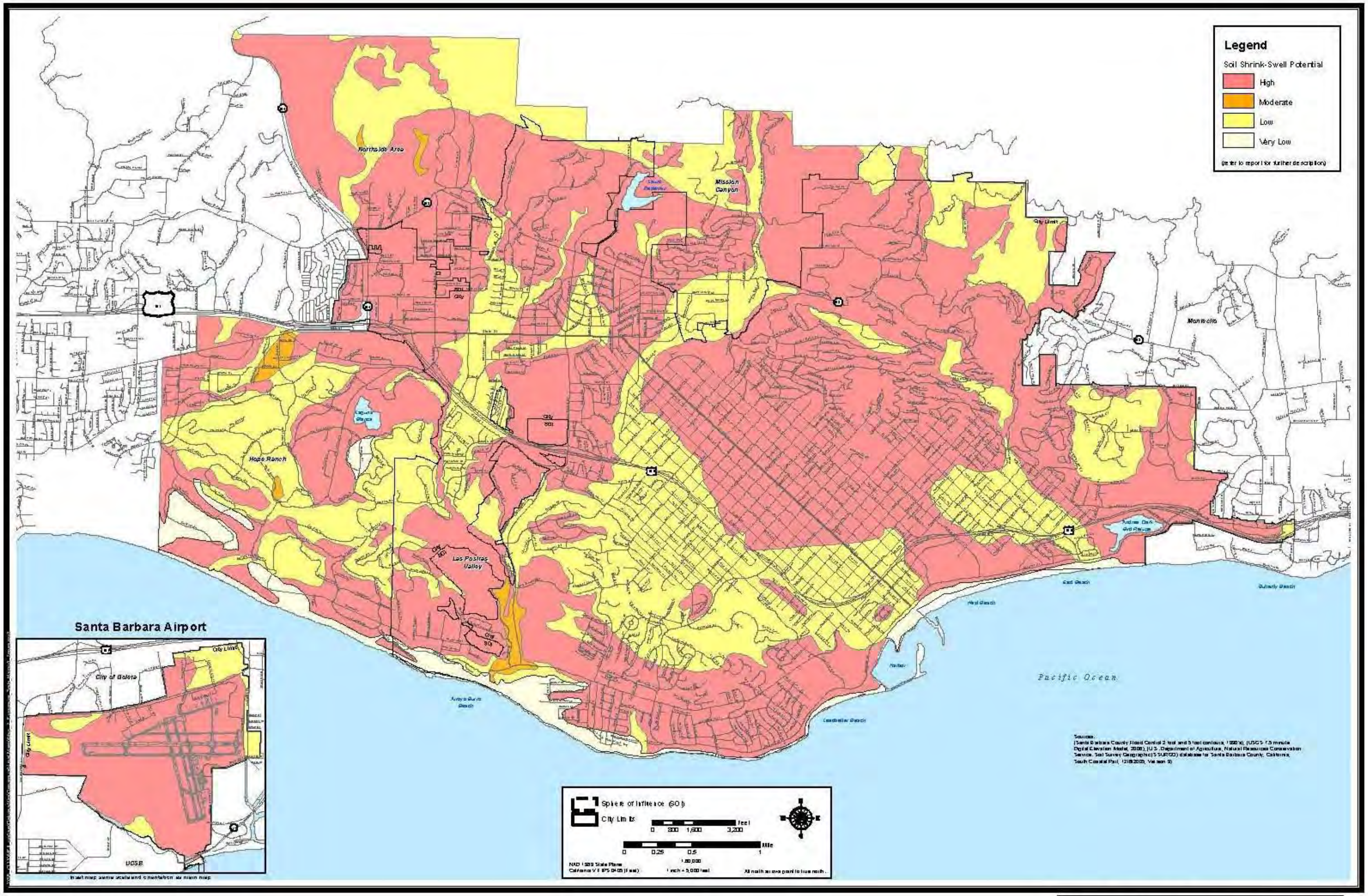
Local Conditions

Soils located in the City that present a potential shrink/swell hazard were identified by the Geology and Geohazards Technical Report based on soil characteristic data obtained from the U.S. Department of Agriculture – National Resource Conservation Service. The potential for soils to result in a shrink/swell hazard were classified on a scale ranging from "High" to "Very Low," and are depicted on Figure 16, Expansive Soil Hazard Zones. In general, areas that are underlain with soils that have a "High" shrink/swell potential are located throughout the City, but predominately in the Downtown, Mesa, and hillside areas in the northern and western portions of the City.

Hazard Reduction

The *Geology and Geohazards Technical Report* provides recommendations regarding the evaluation of potential expansive soil hazards at development project sites. The *Technical Report* indicates that a site-specific expansive soil investigation is not required for development projects, other than essential facilities, located in areas designated as having a "Very Low" or "Low" hazard potential. During site evaluations, local soils engineers may conduct one or more expansivity test at sites with marginal potential for expansive soils. In areas designated as having a "Moderate" or "High" expansive soil potential, a site-specific soil investigation should be prepared for all development projects. The *Technical Report* also describes the type of information that should be included in a project-specific evaluation. In general, the assessment is to be consistent with requirements of applicable building codes. Please refer to the *Geology and Geohazards Technical Report* for a complete description of the recommended hazard evaluation and study requirements.

Expansive soil hazards can be addressed if considered early in a development project's design. Specific foundation preparation and/or structure designs are generally capable of minimizing damage that may result from the presence of expansive soils.



City of Santa Barbara
General Plan
Expansive Soils
Hazard Zones

Figure 16

RADON

Description of the Hazard

Radon is an invisible and odorless radioactive gas that is created as a result of the decay of uranium and thorium that is naturally present in rocks and soils. Breathing air with elevated levels of radon gas can result in an increased risk of developing lung cancer.

The average uranium content in the earth's continental crust is about 2.5 to 2.8 parts per million, although certain rock types and soils derived from those rocks can have substantially higher concentrations. As radon gas is produced it moves through rock fractures and soil pore spaces. Movement of radon gas away from its site of origin is typically on the order of tens of feet, but may be up to 100's of feet. The decay of uranium and thorium can produce several radon isotopes, although radon-222 is the most commonly detected isotope because it has the longest half-life of 3.8 days.

Radon gas moves from the soil and into buildings in various ways. It can enter through cracks in slabs or basement walls, pores and cracks in concrete blocks, and openings around pipes. Since radon enters buildings from the adjacent soil, concentrations of the gas are generally highest in basements and in ground floor rooms. Small amounts of radon can also enter buildings that use private wells if water drawn from the well contains dissolved radon gas.

The U.S. Environmental Protection Agency (EPA) reported in 1991 that the average radon concentration for indoor air in American homes is about 1.3 picocuries per liter (pCi/L).[7] The average radon concentration in outdoor air is about 0.4 pCi/L. While all buildings have some potential for elevated radon levels, buildings located on rocks and soil containing elevated levels of uranium or thorium will have a greater likelihood of having elevated radon concentrations. The EPA and the California Department of Public Health recommends that individuals avoid long-term exposures to radon concentrations above 4 pCi/L.

Not everyone exposed to radon will develop lung cancer. The EPA and National Cancer Institute estimate that there are between 7,000 and 30,000 annual lung cancer deaths in the U.S. attributable to radon.

Local Conditions

In 1993 the U.S. Geological Survey, along with various state agencies, evaluated each county in the U.S to identify potential radon hazard zones. In California, Santa Barbara and Ventura Counties were the only counties in the state identified as having predicted average indoor radon concentrations above 4 pCi/L. This rating is attributed to the presence of Rincon Shale and Monterey Shale Formations in various locations throughout both counties.

Areas of the City that have a moderate to high potential for elevated radon concentrations were identified by the *Geology and Geohazards Technical Report* and are depicted on Figure 17, Radon Hazard Zones. Areas designated as having a "High" or "Moderate" radon potential are generally located in areas underlain by the Rincon or Monterey Formations, or soils derived from those formations. In general, areas designated as having a "High" or "Moderate" risk potential are located in the upper elevations of the Riviera and Upper State Street area, and portions of the Mesa and Las Positas areas.

[7] A picocurie is one trillionth of a Curie, an international measurement unit of radioactivity.

The California Department of Public Health collects building radon test data by zip code to identify areas that have the potential to have high indoor radon levels. Radon data collected by the Department of Public Health for the City of Santa Barbara is summarized below on Table 4. The data indicates that the highest numbers of tests have been conducted, and the highest percentage of tests results with radon concentrations above 4pCi/L are located in the northern areas of the City, which were also identified as having a "High" potential hazard risk on Figure 17.

Table 4
Santa Barbara Radon Test Result Data

Zip Code	General Area	No. of Reported Tests Conducted	No. of Reported Tests above 4pCi/L
93101	Downtown and Westside	70	1
93103	Lower Riviera and Eastside	84	8
93105	Upper Riviera, Upper State and portions of Las Positas. This zip code also includes unincorporated areas north of the City	352	91
93109	Mesa and parts of Las Positas	104	4

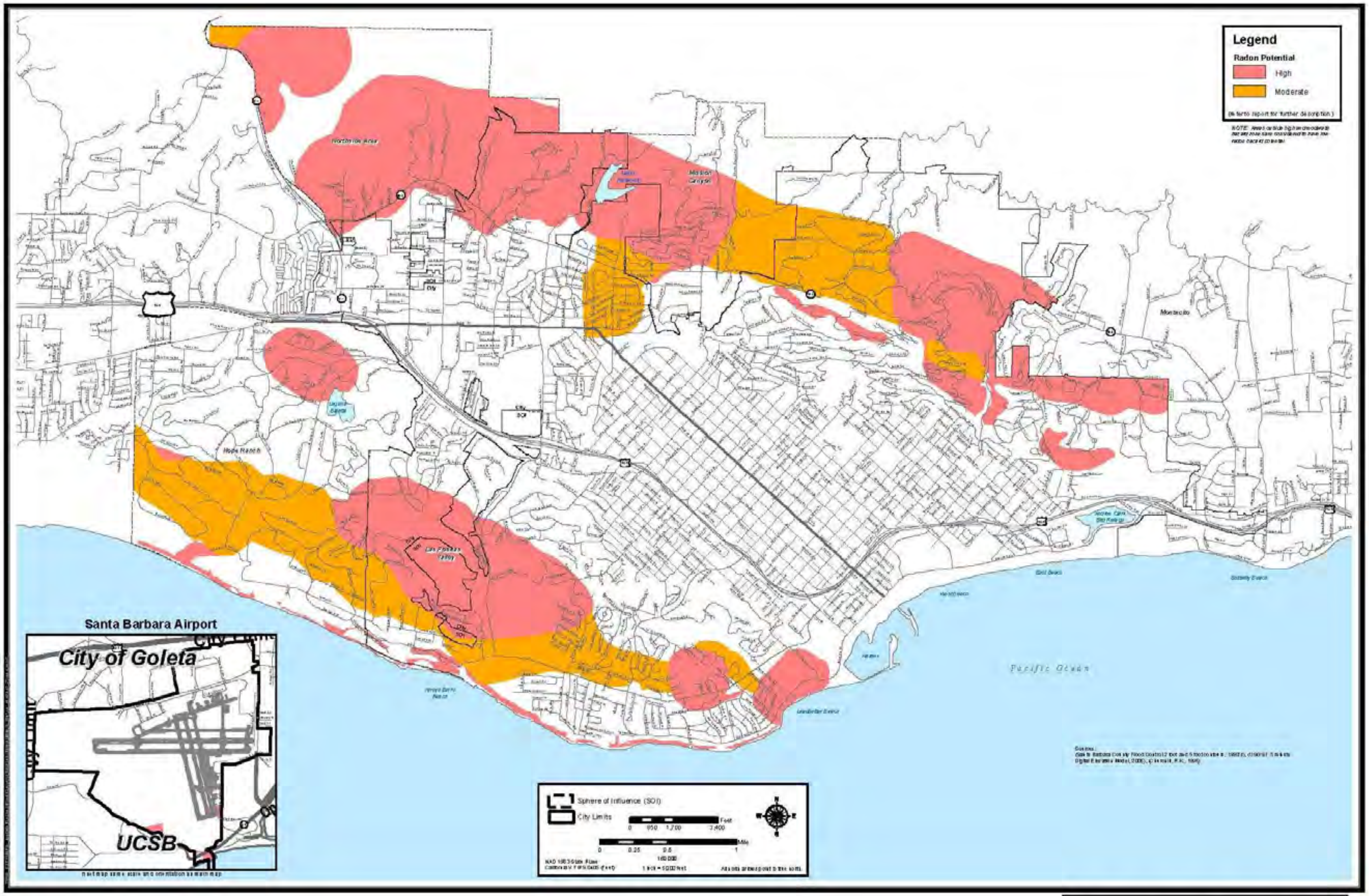
Source: California Department of Public Health, 2012. The data provides test results through May 4, 2010.

Hazard Reduction

The *Geology and Geohazards Technical Report* provides recommendations regarding the evaluation of potential radon exposure hazards at development project sites. The *Technical Report* indicates that in areas designated as having a "Moderate" or "High" hazard potential, new development, other than the construction of minor improvements, should incorporate engineered controls into the design of structures. No hazard evaluation or control measures are required for new development located in areas located beyond the potential hazard areas identified by Figure 17. Please refer to the *Geology and Geohazards Technical Report* for a complete description of the recommended radon hazard evaluation and control requirements.

A common method to minimize the potential for exposure to radon is to install a soil depressurization system that uses a fan and ventilation pipes to create a vacuum below the building slab or a crawl space below an impermeable plastic sheet. Passive ventilation systems that do not rely on the use of a fan can be installed in new construction. Sealing foundation cracks, pipe penetrations and utility channels can also be an effective measure to reduce indoor radon concentrations.

Risk levels at individual homes can vary substantially based on local variability in soil permeability, building design and condition, and building use. Inexpensive and easy to use kits to test indoor air for the presence of radon are available to assess potential hazard risks at individual buildings.



City of Santa Barbara
General Plan
Radon Hazard Zones

Figure 17

HIGH GROUNDWATER

Description of the Hazard

High groundwater or near-surface groundwater is a hazard that can have an adverse effect on building construction, roads, storage tank installation, utility installation, and other projects with structural elements that penetrate the subsurface. Once installed, buildings and other facilities in areas with high groundwater can be subjected to moisture intrusion and, in some cases, tremendous buoyancy forces that may push up on the structure, potentially causing structural offsets at the ground surface or otherwise causing extensive damage. In general, groundwater within 15 feet of ground surface can create a nuisance and can require special structure design to address buoyancy and moisture intrusion. Large, deep structures may have issues with water deeper than 15 feet. During construction, specific steps to de-water excavation areas and provide side slope stability may be necessary in areas of shallow groundwater. In areas of chemical spills, de-watering may mobilize contaminant plumes or, at a minimum, may require permitted treatment systems to remove contaminants prior to discharge of the removed groundwater. High groundwater can also increase liquefaction and the slope stability hazards.

Local Conditions

Groundwater levels can vary over time in response to climatic conditions. In general, the periods of highest groundwater can be expected during and sometimes for several months after rainy seasons with above-average rainfall totals. Recent very high rainfall seasons included 1998 (rainfall at 204% of 139-year average) and 2005 (166% of 139-year average). As expected, a review of various data from groundwater monitoring sites located throughout the City indicated that shallow groundwater levels peaked in those years.

A uniform, shallow groundwater body is not typically found in portions of the City underlain by bedrock. However, buildings located on pads cut into hillsides can sometimes be affected during periods of wet weather by shallow water in fractures or pore spaces in contact with foundations and basements.

Areas of the City that have the potential to be affected by high groundwater are depicted on Figure 18. Areas that generally have potentially shallow groundwater, moderately shallow groundwater, and deep groundwater were identified by reviewing various geotechnical investigations, other readily accessible data sources and a publically accessible database maintained by the California State Water Resources Control Board (GeoTracker). Locations with shallow groundwater data were chosen based on their special positioning and the amount of available historic data. Sites with data from the wet years of 1995, 1998, and/or 2005 were preferred in order to identify reasonable peak groundwater elevation values. Areas of the City depicted on Figure 18 as having potentially shallow groundwater are those areas where groundwater could be encountered at a depth of less than 15 feet below the ground surface, although over time and due to climatic conditions, there can be substantial variability in groundwater levels at a particular site. In general, neighborhoods in the City that have the potential for high groundwater-related hazards include East Beach, the southern portion of the Eastside, Milpas, Lower East, Lower State, the southern portion of Downtown, the southern portion of Laguna, Lower West, West Beach, the southern portion of the Westside, the Waterfront and Airport, and areas located adjacent to the major creeks in the City.

Hazard Reduction

The first step to reduce potential adverse effects of high groundwater is to review available data for the site or nearby areas. The GeoTracker database can be very useful, especially if data from the recent peak years (1995, 1998, 2005) is available. Ground surface elevations should be considered when comparing depth-to-water measurements between sites with varying elevations. Deep aquifer or production well data may not reflect actual shallow groundwater depth, as data from deeper water wells may not provide accurate information for depth to groundwater in the uppermost saturated portions of the subsurface. Site specific investigation (soil borings and/or cased wells/piezometers) will provide up-to-date depth to groundwater data. Upon determination of a "design groundwater elevation," the structure design and building methods can be evaluated and planned as necessary to mitigate the hazard.


Shallow Groundwater Hazard Zones
Legend
Deep Groundwater
Moderately Shallow Groundwater
Potentiallly Shallow Groundwater
City Limits
Map Date: November 2012
0 0.25 0.5 1 Mile
NAD 1983 State Plane
California V FIPS 0405 (Feet)
Base map prepared by City of Santa Barbara, Planning Division, Nov 2011
CAMPBELL-GEO, INC.
Engineering Geology • Hydrology • Geoenvironmental Services
Seal of the City of Santa Barbara California
SANTA BARBARA AIRPORT
CITY OF GOLETA
UCSB
Lauro Reservoir
Laguna Blanca
Andre Clark Bird Refuge
Mission Canyon
Mountain Dr
Foothill Rd
State St
Las Alturas Rd
Alameda Padre Serra
Sycamore Canyon Rd
Hot Springs Rd
Alston Rd
Summit Rd
Olive Mill Rd
Coast Village Rd
Cabrillo Blvd
Cliff Dr
Shoreline Dr
La Marina Dr
Meigs Rd
Braemar Dr
Campanil Dr
Modoc Rd
Las Positas Rd
La Cumbre Rd
San Roque Rd
Ontare Rd
Alamar Ave
Constance Ave
Mission St
Valerio St
Victoria St
Garden St
Micheltorena St
De La Vina St
Castillo St
Robbins St
San Andres St
Carrillo St
Haley St
Milpas St
Yanonali St
Voluntario St
Salinas St
Calle Cesar Chavez
Cieneguitas Creek
Arroyo Burro Creek

Fire Hazards

INTRODUCTION

Two types of fire hazards have the potential to affect Santa Barbara: fires that occur in "wildland" areas, and structure fires in urban areas. The City of Santa Barbara Fire Department is largely staffed and equipped for structure fire protection, but in recent years has placed greater emphasis on planning for wildland fire protection and prevention. This section of the Safety Element provides a description of both wildland and structure fire hazards that have the potential to affect the City, and describes measures that have been implemented to minimize the risk of fire-related hazards.

WILDLAND FIRE HAZARDS

Description of the Hazard

Wildland fires are natural process that can have ecological benefits to the long-term vitality of chaparral and other types of habitat. However, wildland fires can result in a multitude of adverse effects on the built environment, including the potential for loss of life, damage or destruction of public and private structures, loss of personal property, damage to infrastructure systems, and damage to recreation facilities and open space areas. Wildland fires can also result in the loss of hillside vegetation over extensive areas, which can result in a variety of adverse post-fire effects. The loss of protective vegetation can result in substantial increases in stormwater runoff, erosion and sedimentation, and can substantially increase the potential for and severity of landslides, mudslides and downstream flooding. A fire-related increase in these hazards may impact areas not directly affected by the fire and may result in extensive damage to downstream homes, roads, debris basins and other drainage and utility infrastructure, the impairment of water quality, and adverse impacts to aquatic habitats.

A wildland fire that occurs in the vicinity of urban development is often referred to as a "wildland-urban interface" fire. These types of fires have been described as occurring in "*the area or zone where structures and other human development meet or intermingle with undeveloped wildland or vegetative fuels.*"[8] Wildland-urban interface fires can occur where there is a distinct boundary between the built and natural areas, or may occur in areas where development and infrastructure is intermixed with the natural area. In large wildland-urban interface fires, the fire may be fueled by structures as well as native and landscape vegetation. The 2008 Tea Fire and the 2009 Jesusita Fire are recent examples of large wildland-urban interface zone fires in the Santa Barbara that resulted in extensive damage to structures and infrastructure. In contrast, the 2007 Zaca Fire burned over 220,000 wildland acres in northern Santa Barbara County, was one of the largest fires ever to occur in California, and did not burn any structures.

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[8] State of California Multi-Hazard Mitigation Plan, 2010

Wildland-urban interface zones are often designated as having a high wildfire hazard potential due to a combination of factors that increase the risk of a wildland fire. Property owners can implement a variety of construction and vegetation management practices to reduce the potential for wildfire-related damage, but must also accept the risk associated with living in a high fire hazard environment. Additional information regarding local wildfire hazard conditions and risk reduction programs is provided below.

Due to the extensive environmental, social and monetary costs associated with wildfires, federal, state and local agencies have implemented a wide variety of fire prevention and suppression programs. To alert firefighting agencies and the public of weather conditions that may contribute to the start or rapid spread of a fire, such as low humidity, high winds and/or lightning storms, the National Weather Service may issue a "Red Flag Warning." Such a warning is often used by local agencies to increase staffing and equipment resources, and to temporarily ban outdoor fires and other possible fire ignition sources. When a wildfire does occur, most communities, including Santa Barbara, rely on mutual aid resources to supplement local fire suppression capabilities. Mutual aid may be provided by neighboring agencies, fire departments location throughout the state, as well as state and federal resources. The California Department of Forestry and Fire Protection (CAL FIRE) is a state agency that assists fire departments with mutual aid efforts and suppression capabilities. In extreme emergencies, California National Guard resources may also be utilized, such as helicopters, support personnel and communications equipment. State and federal mutual aid support may also be provided by the California Emergency Management Agency and the U.S. Forest Service.

Local Conditions

Conditions that Contribute to a High Wildfire Hazard

Natural- and development-related conditions can combine to increase the potential for and the severity of wildland fires. Based on an evaluation of these conditions, the Santa Barbara Fire Department has identified areas of the City that have a high wildfire hazard. Conditions that contribute to a high wildfire hazard are briefly described below.

Vegetation. Much of the wildland area within and adjacent to Santa Barbara is covered with a plant community known as chaparral, which commonly consists of species such as chamise, manzantia and ceonothus. This plant community has evolved so that fire has become a natural part of the ecosystem and is periodically required to clear old plants and accumulated dead plant material so that new plant growth can occur. Fire exclusion and suppression practices have resulted in large accumulations of these highly flammable plant materials in certain hillside areas, and when burned under wildfire conditions, the result is intense fire behavior that increases the potential for damage to natural and developed resources.

Climate. The local Mediterranean climate is characterized by moist winters that promote plant growth, and dry summers that lower vegetation (fuel) moisture levels making the plants susceptible to fire. Short-term weather conditions, such as Santa Ana and sundowner winds, can result in strong, hot winds that lower fuel moisture levels and cause flames to spread rapidly and erratically. Additional information about sundowner winds is provided on Figure 19.

Topography. Steep slopes can substantially limit the ability of firefighters to reach and fight fires. Steep terrain also channels air flow, which can create erratic wind patterns and influence the direction and speed at which a fire spreads.

Road and Driveway Requirements. The Fire Department has adopted access standards for new development in high fire hazard areas, and those standards address items such as road width, gradient, surface material, vertical clearance, turning radius, dead ends, bridges and address requirements. Development that occurred in high fire hazard areas prior to the adoption of current standards often does not meet the existing requirements, which can impede the ability of the Fire Department to fight fires and result in safety issues for fire fighters. Access along roadways that otherwise meet current standards can be constrained by on-street parking and vegetation that has been allowed to grow close to the roadway.

Water Supply. The Fire Department has adopted water supply and fire hydrant standards for development in high fire hazard areas. These standards were adopted after the 1977 Sycamore Canyon fire when water supply systems were not able to provide adequate water pressure and volume. New water systems have been developed in high fire hazard areas that provide additional reservoirs, pump stations, water mains and fire hydrants. Despite these improvements, water supply may be limited in some high wildfire hazard areas during a fire emergency because of the high demand placed on the water system.

Figure 19

SUNDOWNER WINDS IN SANTA BARBARA

Sundowner winds generally occur in the late afternoon or evening, resulting in gentle offshore breezes and a rise in temperature. Stronger sundowners may occur several times a year and can result in a large temperature rise and local gale-force winds. Rarely, probably only several times a century, an "explosive" sundowner occurs resulting in extremely strong and hot winds. In these events, super-heated air from the Santa Ynez Valley races down the mountains onto the Santa Barbara coastal plain.

A phenomenal sundowner occurred on June 17, 1859 and was recorded by a survey boat anchored off Santa Barbara. The ship record indicates that temperatures were in the 80's by mid-morning, and at approximately 1 p.m. gusty winds developed and the temperature began to rise. At 2 p.m. the survey boat recorded a temperature of 133 degrees and heavy blowing dust. A U.S. government report stated "calves, rabbits and cattle died on their feet. Fruit fell from trees to the ground scorched on the windward side; all vegetable gardens were ruined. A fisherman in a rowboat made it to the Goleta Sandspit with his face and arms blistered as if he had been exposed to a blast furnace." By 5 p.m. the temperature dropped to 122 degrees, and by 8 p.m. it had cooled to 77 degrees.

The temperature of 133 degrees was the highest recorded temperature in North America for 75 years until a temperature of 134 degrees was recorded in Death Valley.

Response Time. The Santa Barbara Fire Department's response time standard, which is the amount time between receiving a call for service and arriving at the scene, is four minutes. Most of the City can be reached by a responding fire engine within the four-minute standard, however, several high fire hazard areas require more than a four-minute response time. An extended fire response time increases the potential for a fire to escape initial control, which increases fire risk to surrounding areas. Areas of the City that are located beyond the four-minute response standard include the Eucalyptus Hill neighborhood, the northern portion of the Cielito neighborhood, the extreme northern portion of the Foothill neighborhood, and the western portion of the Campanil neighborhood.

High Fire Hazard Areas in Santa Barbara

The Fire Department has identified four high fire hazard zones in the City based on fire hazard and risk factors identified and evaluated by the Department's 2004 Wildland Fire Plan. Each of the identified fire hazard zones presents a varying level of hazard risk. The four wildland fire hazard zones identified by the Wildland Fire Plan are depicted on Figure 20 and include the:

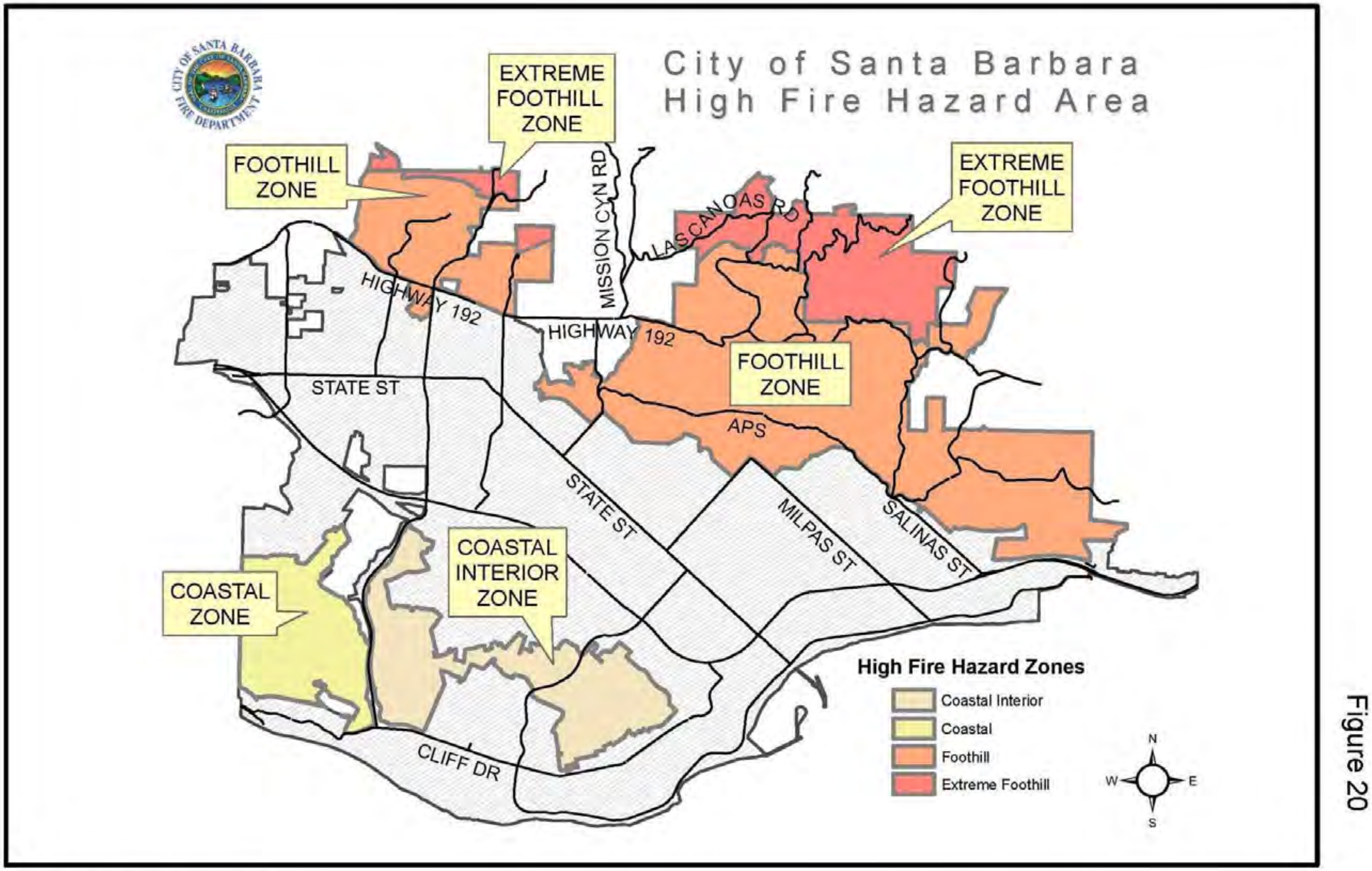
Extreme Foothill Zone, Foothill Zone, Coastal Zone and Coastal Interior Zone. Characteristics that contribute to the high wildfire hazard condition in each of the zones are summarized below.

Extreme Foothill Zone. Areas of the City in the Extreme Foothill Zone are located in what is roughly the northern half of the Cielito neighborhood, and the northern-most portion of the Foothill neighborhood. This zone has a combination of heavy vegetation located within the City and in the adjacent Los Padres National Forest; slopes with a gradient greater than 30 percent and that face to the south and southwest; and drainages that are aligned to frequent hot and dry wind conditions. The majority of this zone is outside the Department's four-minute response time, and there are areas within the zone that have limited water supplies. The main roads in this zone meet Fire Department access standards; however, many smaller roads, driveways and bridges do not meet current standards. The majority of this zone is outside the Department's four-minute response time, and there are areas within the zone that have limited water supplies. Portions of this area have been burned during recent fires, including the Coyote (1964), Sycamore Canyon (1977), Painted Cave (1990), Tea (2008) and Jesusita (2009) fires.

Foothill Zone. The Foothill Zone includes all or portions of the Cielito, Riviera and Lower Riviera, Eucalyptus Hill and Foothill neighborhoods. Vegetation in this area includes a mix of heavy brush and canopy fuels provided by oak and eucalyptus trees; heavy vegetation in creek areas; and slopes with gradients that vary between 20 and 40 percent and that are oriented to the south and southwest. The majority of this zone is within the Fire Department's four-minute response area, however, some of the main roads and many of the smaller residential roads do not meet the Department's road standards. This zone generally has adequate water supplies, which reduces potential fire hazards, however, the high density of residential structures located throughout this zone increases the wildfire hazard. This zone has been affected by several wildfires, including the Coyote (1964), Sycamore Canyon (1977), Tea (2008) and Jesusita (2009) fires.

Coastal Zone. The Coastal high fire hazard zone is located in the southwestern portion of the City and consists mostly of the Campanil neighborhood. This zone has diverse pockets of vegetation, such as chaparral, oak forests, coastal sage scrub, landscape vegetation, agricultural lands and eucalyptus groves, and much of the vegetation occurs on slopes that range in gradient from 10 to 35 percent. The ocean's influence dominates weather patterns in this zone for most of the year, however, down canyon winds that can cause the rapid spread of flames may be a factor. The western portion of this zone is located beyond the Fire Department's four-minute response time standard. The majority of the roads in this zone meet the Fire Department's standards and water supplies also meet Fire Department requirements.

Coastal Interior Zone. The Coastal Interior high fire hazard zone includes all or portions of the Bel Air, Alta Mesa, and Westside neighborhoods. This zone has areas with moderate brush and heavy canopy fuels that are interspersed among areas with high concentrations of structures. The ocean's influence dominates weather patterns most of the year, however, down canyon winds can cause the rapid spread of flames on slopes that vary in gradient between 10 and 35 percent. This zone is within the Fire Department's four-minute response time standard, and the majority of the roads meet Fire Department's standards. This zone also meets the Fire Department's water supply standards.



Source: City of Santa Barbara, 2012

City of Santa Barbara
General Plan
High Fire Hazard Zones

Structures that May be Affected by Wildfires

The *Wildland Fire Plan* (2004) evaluated fire hazards based on a variety of factors, including the number of structures located in areas that are subject to wildfire hazards. The *Wildland Fire Plan* determined that there were 138 structures in the Extreme Foothill zone, 4,308 structures in the Foothill zone, 570 structures in the Coastal zone, and 365 structures in the Coastal Interior zone. While the actual number of structures located in each high fire hazard zone will vary somewhat over time, the data provided by the *Wildland Fire Plan* is indicative of the relative hazards associated with potential structure damage and loss due to wildfire in the various hazard zones that have been identified in the City.

As part of the Santa Barbara Annex to the *Multi-Jurisdictional Hazard Mitigation Plan,* a vulnerability assessment was conducted to identify City-owned facilities that could be adversely affected by wildfire hazards. The facilities included in the assessment consisted mostly of utility, government, public safety and other infrastructure structures. The vulnerability assessment identified 20 individual structures or buildings located in what the *Hazard Mitigation Plan* identified as having a "very high" fire hazard. The areas determined to have a "very high" fire hazard generally correspond to the Extreme Foothill and Foothill high fire hazard zones depicted on Figure 20. The facilities identified by the *Hazard Mitigation Plan* as being located in a very high hazard zone include the Cater Water Treatment Plant, and the Skofield and Bothin pump stations.

Recent Wildland Fires in the Santa Barbara Area

Wildland fires have been a significant part of Santa Barbra's history. Between 1964 and 2012, seven major wildfires have occurred in the Santa Barbara "front country," which is the area along the south-facing slope of the Santa Ynez Mountains between the Gaviota Pass to the west and the Santa Barbara/Ventura County line to the east. In total, these seven fires have burned over 100,000 acres, destroyed over 1,100 structures, and resulted in six fatalities. A summary of the major wildfires that have occurred in the Santa Barbara area since 1964 is provided on Table 5, and the areas affected by recent fires are depicted on Figure 21. Additional information regarding the 2008 Tea Fire and the 2009 Jesusita Fire is provided on Figure 22.

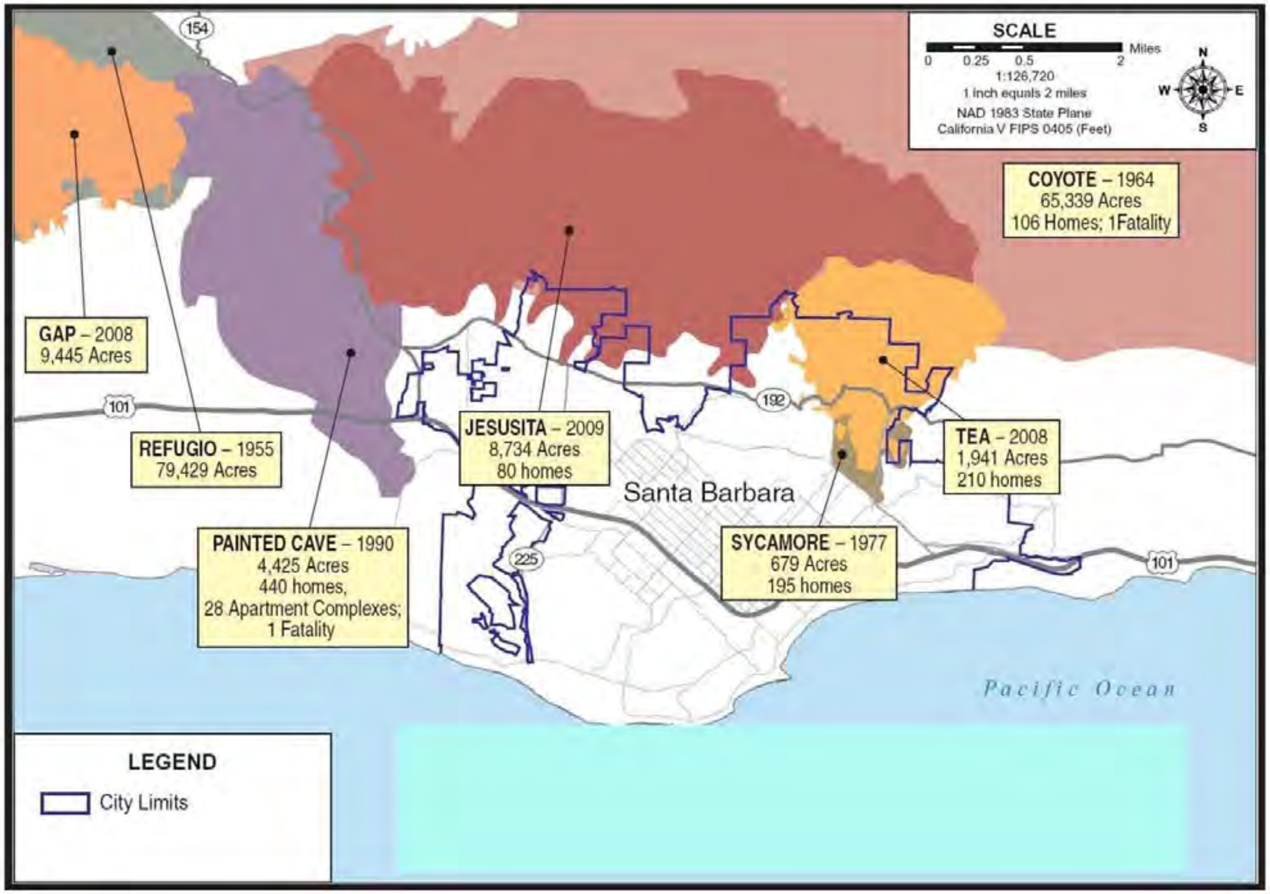


Figure 21

Source: Santa Barbara General Plan Update Program EIR, 2010

City of Santa Barbara
General Plan
Santa Barbara Region Recent Wildfires

Table 5
Recent Wildfires in the Santa Barbara Front Country

Fire	Year	Acreage Burned	Structures Lost	Fatalities
Coyote	1964	67,000	106 homes	1
Romero	1971	14,538	4 homes	4
Sycamore Canyon	1977	805	195 homes	0
Painted Cave	1990	4,900	440 homes 28 apartments 30 other structures	1
Gap	2008	9,445	0 homes 4 structures	0
Tea	2008	1,940	210 homes	0
Jesusita	2009	8,733	80 homes 1 commercial property 79 other structures	0

Post-Fire Recovery

The City has implemented a variety of programs and procedures to assist property owners that have been affected by recent wildfires. Information and assistance can be obtained regarding a variety of fire-related reconstruction requirements, including debris removal; erosion control; development requirements for non-conforming buildings; requirements for soils reports; review and construction requirements for main and accessory structures; and the temporary use of residential trailers during construction. As part of the rebuilding effort, the City encourages homeowners to incorporate fire prevention, energy efficiency and sustainability measures into proposed residence designs.

Possible Effects of Climate Change on Wildfire Hazards

It is anticipated that future effects of climate change will include decreased precipitation, increased temperature, longer and more frequent periods of drought, and periodic high rainfall events that could result in an increase in the growth of grasses and other "flashy" fuels. Climate change-induced stresses on plant communities could also make them more susceptible to pests and disease, which could result in an increase plant in mortality and additional accumulations of dead plant material. Each of these conditions, or a combination of these conditions, would have the potential to result in an increase in the frequency and severity of wildfires in the Santa Barbara area. An increased risk for wildfires will place additional importance on the use of fire resistant construction techniques and the implementation of vegetation management programs, particularly in wildland–urban interface areas.

Figure 22

RECENT WILDFIRES IN SANTA BARBARA

The Jesusita Fire of 2009 burned the foothills north of and in the City of Santa Barbara.
(photo source: samedwardsfamily.com)

The 2008 Tea Fire started in Montecito on November 13 at 6:30 pm and was not controlled until November 17. Driven by sundowner winds gusting up to 70 miles an hour, the fire burned 1,940 acres and destroyed 210 homes. 106 of the burned homes were located in the City of Santa Barbara. A total of 2,235 firefighters and nine helicopters were used to fight the fire. Total suppression costs were estimated to be 5.7 million dollars.

Flames of the Jesusita Fire as seen from the waterfront area. Stearns Wharf is visible in the foreground.
(photo source: samedwardsfamily.com)

The 2009 Jesusita Fire started on May 5, 2009 in an area near Cathedral Peak and burned a total of 8,733 acres and 80 homes. Evacuation orders for affected areas were not lifted until May 13th. In total, 1,857 fire fighters, 111 fire engines, four helicopters and an air attack tanker were used to control the fire. Fire suppression costs were estimated to be 20 million dollars.

Flames from the 2008 Tea Fire are seen from De la Guerra Plaza adjacent to City Hall.
(photo source:a11news.com)

Strong winds blow smoke from the Jesusita Fire across the Santa Barbara Channel.
(photo source: earthobservatory.nasa.gov)

Hazard Reduction

Numerous regulatory requirements and risk reduction programs to minimize the effects of wildfires have been implemented by the City, county, state and federal agencies. In general, these requirements include standards related to fire prevention and suppression, and making structures more resistant to wildfires. Some of the wildfire hazard reduction measures that are implemented by the City of Santa Barbra Fire Department are briefly described below.

Wildland Fire Plan. The Santa Barbara Fire Department prepared the *Wildland Fire Plan* in 2004 to provide a comprehensive and coordinated approach to reducing the impacts of wildland fire. The Plan identifies and evaluates the City's high fire hazard areas, identifies policies and actions to reduce the threat of wildland fire to the community, and provides a process to prioritize and fund implementation of wildland fire risk reduction projects. The Plan identifies a wide range of risk reduction measures, including public education, inter-agency coordination, vegetation/fuel management, evacuation planning and code enforcement.

Building and Fire Code Requirements. The California Building Code (CCR, Title 24) includes wildland-urban interface fire area building standards that apply to new buildings, remodels and additions to structures located in each of the high wildfire hazard zones that have been identified by the Santa Barbara Fire Department. The intent of these regulations is to provide a reasonable level of exterior wildfire exposure protection through the use of ignition resistant materials and design. This building code provides requirements for building-related elements such as roofing material, exterior coverings, decks and accessory structures, exterior doors and windows, roof and attic vents, and building eaves. The high fire hazard area building requirements provided by the California Building Code, plus local amendments, are adopted by the City of Santa Barbara under Municipal Code Section 22.04.

Other standards for development in high fire hazard and wildland-urban interface areas are provided by Santa Barbara Municipal Code Section Title 8, Fire Protection. This section adopts the requirements, with amendments, of the International Building Code and California Fire Code.

Vegetation Management. Vegetation management programs reduce the amount of combustible vegetation that is present in a specified area. By reducing the amount of fuel available to burn during a wildfire, flame lengths and the intensity of the fire will be reduced. Vegetation management is often accomplished through the implementation fuel modification programs that include actions such as removing dead vegetation, thinning plants to reduce the amount of combustible vegetation, removing highly combustible plant species, and providing plants that are more resistant to fire. Other objectives of fuel modification programs are to retain compatibility with adjacent natural landscapes, provide wildlife habitat and maintain ecosystem functions.

Vegetation management activities are often implemented to provide defensible space around structures to create an area that can slow the spread and intensity of a fire, and to provide an area where firefighters can more safely work to save the structure. More information regarding defensible space requirements in the City of Santa Barbra is provided below.

Wildland Fire Suppression Assessment District. The City of Santa Barbara has implemented an assessment district to support the implementation of a variety of vegetation management and fire safety programs for properties located in the Extreme Foothill and Foothill High Fire Hazard Zones (Figure 20). Examples of vegetation management programs that have been implemented in conjunction with Assessment District activities are provided below.

- Community Fuels Treatment Network. This program conducts fuel modification activities in Vegetation Management Units located throughout the Assessment District to reduce fuel loads, particularly in areas adjacent to the dense chaparral vegetation that exists outside of the City limits. Fuel modification actions include the removal of selected exotic (non-native) plants; thinning, pruning and limbing vegetation to remove "ladder"[9] fuels; removing dead plant material; and thinning continuous areas of brush.
- Community Hazard Reduction Project. The Fire Department has implemented this program to work with property owners and neighborhoods to conduct fuel modification activities, particularly in areas that did not burn in the 2008 Tea Fire and the 2009 Jesusita Fire.
- Road Clearance. The purpose of this program is to reduce the amount of vegetation along roadways, which reduces potential evacuation hazards during a wildfire and provides improved access for fire engines and equipment during a wildfire.
- Chipping Service. This service is offered to homeowners to encourage them to create and maintain defensible space around structures, and to provide a cost-effective way to dispose of the cut plant material.
- Defensible Space Inspections. Upon request, the Santa Barbara Fire Department will provide a property inspection and offer recommendations to improve fire safety.

Creek Vegetation Management. The Fire Department generally conducts very little vegetation management in creek areas located in high fire hazard zones. When vegetation management activities in creek areas are deemed necessary, they generally occur outside a 15-foot buffer zone measured from the top of the creek bank. However, the removal of dead brush and exotic plants, using hand tools only, may also occur in areas up to the top of the bank.

On occasion, the Fire Department may determine that more comprehensive vegetation management is required within a creek or within the 15-foot top of bank buffer zone. Conditions that may require limited vegetation management in creek areas may include: an abundance of dead wood in the understory that has resulted in accumulations of "ladder" fuels near structures or key defensible spaces to be used for firefighting; when highly flammable vegetation such as eucalyptus trees, giant reed or pampas grass dominate the riparian corridor and have created hazardous fuel conditions; or high fuel conditions are present in a creek adjacent to a road or bridge that provides emergency evacuation egress or fire fighter access. The Fire Department will prepare a vegetation management plan each time it proposes to conduct work in a creek area, and measures to protect aquatic and riparian resources in the work area will be identified and implemented. In addition, the Department will obtain a Streambed Alteration Agreement (Fish and Game Code 1601) from the California Department of Fish and Wildlife prior to the implementation of the vegetation management work.

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[9] Ladder fuels are live or dead vegetation that allow a fire to climb up from the ground into a tree canopy. Common ladder fuels include tall grasses and shrubs, and low-hanging tree branches.

Defensible Space Requirements. Reducing the amount of vegetative fuel that exists around a building or structure increases the probability of it surviving a wildfire. A defensible space perimeter will also provide firefighters with a safer working environment as a fire approaches, and minimizes the chance that a structure fire will escape to surrounding wildland areas.

Santa Barbara Fire Department's *Wildland Fire Plan* identifies four high fire hazard zones in the City (Figure 20) and recommends defensible space distance standards for each of the hazard zones. The recommended defensible space distance standards were subsequently adopted by the City with the passage of Ordinance No. 5535 (Municipal Code Chapter 8.04). The City's required defensible space distances for each hazard zone are provided on Table 6

Table 6
High Fire Hazard Area Defensible Space Requirements

Hazard Zone	Defensible Space Required From Structures
Coastal Interior	30 to 50 feet
Coastal	50 to 70 feet
Foothill	100 feet
Extreme Foothill	150 feet

Ordinance No. 5535 requires that property owners in the high fire hazard areas maintain native, non-native and landscape vegetation in accordance with the distance requirements shown on Table 7. Ordinance No. 5535 also recommends that defensible space requirements be increased around structures located on slopes with a gradient greater than 20 percent, and provides additional defensible space and landscaping requirements related to items such as annual "weed abatement," horizontal and vertical vegetation clearance requirements from streets and driveways, tree trimming standards, separation distances between plants maintained within required defensible space area, and the use/disposal of brush trimmings.

STRUCTURE FIRE HAZARDS

Description of the Hazard

The City of Santa Barbara Fire Department provides fire prevention, suppression and other emergency response services. In addition to responding to structure fires, the Fire Department responds to medical emergencies, accidents, hazardous material releases and rescues. The Fire Department is also responsible for aircraft emergencies at the Santa Barbara Airport. Non-emergency services provided by the Fire Department include conducting fire and life safety inspections, building inspections, fire code investigations, code compliance, development review and public education.

The risk to life and property resulting from structure fires can be influenced by many factors. Some of the conditions that must be considered when assessing potential structure fire hazards and the appropriate level of fire protection that should be provided include: the availability of adequate water supplies; the size, height and construction characteristics of the structure; the type of use occupying the structure and the type of materials that may be present in the building; and the ability to provide adequate emergency ingress and egress.

Local Conditions

The Santa Barbara Fire Department operates seven fire stations and an aircraft fire fighting station at the Airport. In 2012, the Department has 89 firefighters to serve a resident population of approximately 90,000 people. This results in a fire fighter to resident ratio of almost one fire fighter per 1,000 residents, which is a good service ratio. The Fire Department estimates that during the day when visitors and out-of-town employees are present, the City's population increases to an average of approximately 123,000 people, which decreases the fire fighter to population served ratio. The Fire Department responded to 7,790 alarms in 2011, and of those calls, 5,518 (71%) were for medical emergencies.

Hazard Reduction

The prevention of fires in the urban areas of Santa Barbara is a primary objective of the Fire Department. Regulations to minimize the risk of structure fires are provided by the International Fire Code and the California Fire Code, and these requirements, with amendments, have been adopted by the City under Santa Barbara Municipal Code Chapter 8.04. This Chapter of the Municipal Code also includes a variety of other fire prevention development standards, such as fire hydrant placement and fire flow requirements for residential and commercial structures; road and driveway dimensions; and requirements to install automatic fire sprinklers in new construction and in buildings that are being expanded or altered. Chapter 8.04 also includes requirements related to the avoidance and abatement of fire hazards, weed abatement requirements, and regulation enforcement procedures.

Flooding Hazards

INTRODUCTION

Three types of flooding hazards have the potential to affect Santa Barbara: stream flooding that occurs when stormwater runoff overtops a creek's banks; coastal area flooding caused by ocean tides, sea level conditions and/or storm-generated waves; and the inundation of areas that may occur due to the failure of a dam. This section of the Safety Element provides a description of flooding-related hazards that have the potential to affect the City; describes how climate change may affect stream and coastal area flooding hazards; and describes measures that have been implemented to minimize the risk of flooding hazards.

STREAM FLOODING

Description of the Hazard

Stream flooding occurs when stormwater runoff in a stream channel exceeds the water carrying capacity of the channel, causing water to flow over the stream's banks. Several factors will influence the severity of a flood event, including: rainfall intensity and duration; ground surface permeability; and the geographic characteristics of the watershed, such as its size, shape and slope.

Stream channels located in the Santa Barbara area and their associated watersheds often experience short-duration, high-intensity rainfall events. The upper reaches of the stream's watersheds are generally located in the Santa Ynez Mountains close to the City and have steep topography and shallow soils. These conditions can result in high runoff rates and creek flows that rise quickly, and then drop back to winter base flow levels soon after the intense rainfall stops. Many of the natural creek channels in the City do not have the capacity to convey the sudden increases flood flows that can occur during a large storm, and the areas with the greatest potential to experience out of channel flows are in located in the lower creek reaches where streambed gradients flatten and channel bank tops are relatively low. During high flow events, the creeks can also carry large loads of sediment and debris that can clog drainage facilities and impair flows beneath bridges, which can contribute to the inundation of floodplain areas. A "floodplain" area is the relatively flat or lowland area adjoining a stream that is subject to periodic inundation by floodwater. This area is distinguished from the "floodway," which is the channel of a stream and the adjacent area that must be preserved to discharge floodwater associated with a 100-year flood without cumulatively increasing the water surface elevation more than one foot.

The extent of damage caused by a flood depends a variety of factors, such as topography; the depth and duration of flooding; velocity of flow; the sediment load carried and deposited by floodwaters; the extent of development located in the flooded area; and effectiveness of weather forecasting and flood warnings. While there are some benefits associated with flooding, such as the replenishment of beach sand and nutrients to agricultural land, flooding is generally considered to be a hazard to development. Flooding-related impacts can include injuries and loss of life; damage to structures, property and infrastructure; damage to vegetation; and potential health hazards from ruptured sewer lines and damaged septic tanks.

The magnitude and severity of flood events may be increased by a variety of natural- and development-related conditions. Natural factors can include the excessive growth of brush and trees within drainage channels, which may obstruct stream flows and result in an increase in floodwater heights. Fires within the watershed will result in the removal of vegetation that helps to control the amount and rate of stormwater runoff. Without the protective vegetation, soil erosion is increased and the additional sediment can accumulate in drainage channels and decrease their water carrying capacity. Urban development often results in an increase in impervious surface areas, which changes the drainage area's storm water runoff characteristics. These effects are referred to as "hydromodification" and can result in increased stormwater runoff volume, velocity, temperature, and discharge duration. Hydromodification can also result in increased erosion and sedimentation, and may also contribute to increases in pollutants in runoff water. The combined effect of more runoff reaching the stream channel sooner can substantially increase flooding-related hazards and result in more severe and frequent floods. Urban development can also result in the placement of structures and fill material in floodplain areas, which reduces the space available for holding floodwater and increases water levels and flow rates.

To protect urban development from the impacts of flooding, stream channels are often "channelized" (i.e., straightened and/or lined with concrete or other material) to move water through the channel more efficiently. However, as runoff water emerges from the channelized section of the stream, it is often delivered to an unchannelized down-stream section at velocities that the natural section of the stream is not capable of adequately carrying. This can result in increased flooding impacts downstream and erosion of the stream bed and banks.

Floods are generally described in term of their frequency of occurrence. For example, a 100-year flood is defined by evaluating the long-term average time period between floods of a certain size, and identifying the size of flood that has a one percent chance of occurring during any given year. A recurrence interval such as a 25-year or 100-year flood represents only the long-term statistical average time period between floods of a specific size. Floods of any size may occur at much shorter intervals or even within the same year.

Stream flow is generally measured in terms of peak discharge, which is the maximum volume of water passing a point along the channel during a given time interval, such as cubic feet per second. The volume and velocity of stream flow is an important factor that influences the physical characteristics of a stream channel, the stream's ecosystem, and flooding potential.

Local Conditions

Santa Barbara Area Watersheds and Creeks

Four major watersheds drain through the City of Santa Barbara to the Pacific Ocean. The creeks that drain those watersheds include Arroyo Burro Creek, Mission Creek, Sycamore Creek and the Laguna Channel. The Arroyo Burro, Mission and Sycamore Creeks originate in the Santa Ynez Mountains and drain areas within the Los Padres National Forest as well as developed areas of the City. The Laguna Channel watershed drains an almost entirely urbanized watershed within the City. The locations of each of these watersheds are depicted on Figure 23. Additional information about each of the City's major watersheds is provided below and on Table 7.

Flows in the City's creeks are highly variable due to the seasonal pattern of rainfall that occurs in the project region. Rainfall is concentrated in the winter months, ranging from about 18 inches per year on the coastal plain, to as much as 32 inches per year in the mountains north of the City. As a result, significant flows in the creeks generally occurs only during winter and spring months.

Arroyo Burro Creek. Arroyo Burro Creek begins in the Santa Ynez Mountains and has two main tributaries in the upper reaches of the watershed: San Roque Creek and Barger Creek. Barger Creek joins Arroyo Burro Creek near Foothill Road (SR 192), and San Roque Creek converges with Arroyo Burro Creek south of the Upper State Street. A 1,400-foot segment of Arroyo Burro north of U.S. Highway 101 was realigned and channelized to accommodate construction of the highway. Two minor tributaries also converge with Arroyo Burro Creek along its lower reaches: Las Positas Creek, which joins the main channel northwest of Elings Park; and Mesa Creek, which joins the main channel near Arroyo Burro County Park and the tidally influenced lagoon that has formed at the end of Arroyo Burro Creek.

Mission Creek. Mission Creek begins in the Santa Ynez Mountains about three quarters of a mile north of the Santa Barbara Botanical Gardens and has two major tributaries: Las Canoas Creek and Rattlesnake Creek, both of which join the Mission Creek channel near Foothill Road. Mission Creek enters the City near the Museum and Natural History and Mission Santa Barbara, and then extends through urbanized areas until it reaches the ocean east of Stearns Wharf where it forms a tidal lagoon that extends to the east of the wharf. The size of the lagoon can vary considerably depending upon flows in the creek, the beach sand berm, and tide conditions. Segments of the lower reaches of Mission Creek have been extensively modified. A segment about three quarters of a mile long extending roughly between Arrellaga Street and Canon Perdido Street adjacent to U.S. 101 has been channelized with concrete walls. The channelization project cut off an “oxbow” or bend in the creek channel that was formerly located on what is now the west side of the highway in the vicinity of Bohnett Park. In many areas between Canon Perdido Street to the creek mouth, the creek’s banks have been “armored” to protect adjacent development from bank erosion and flooding impacts. As the creek approaches the ocean its gradient becomes relatively flat and the adjacent areas are subject to periodic flooding.

Table 7
City of Santa Barbara Major Watershed Characteristics

Watershed/ Creek Name	**Watershed Area** (acres)	**Creek Length** (miles)	**Jurisdiction** (acres/percentage of total watershed)			**Watershed Development Characteristics**
			Los Padres National Forest.	**City of Santa Barbara**	**County of Santa Barbara**	
Arroyo Burro Creek	5,633	7+	2,522/45%	2,537/45%	574/10%	77% open space 23% urban
Mission Creek	7,418	7.5	3,256/44%	3,021/41%	1,141/15%	68% open space 32% urban
Sycamore Creek	2,590	5	613/24%	1,427/55%	550/21%	66% open space 24% urban
Laguna Channel	2,022	na	0/0	1,983/98%	39/2%	21% open space 79% urban

na: most of the channel is constructed storm drain facilities

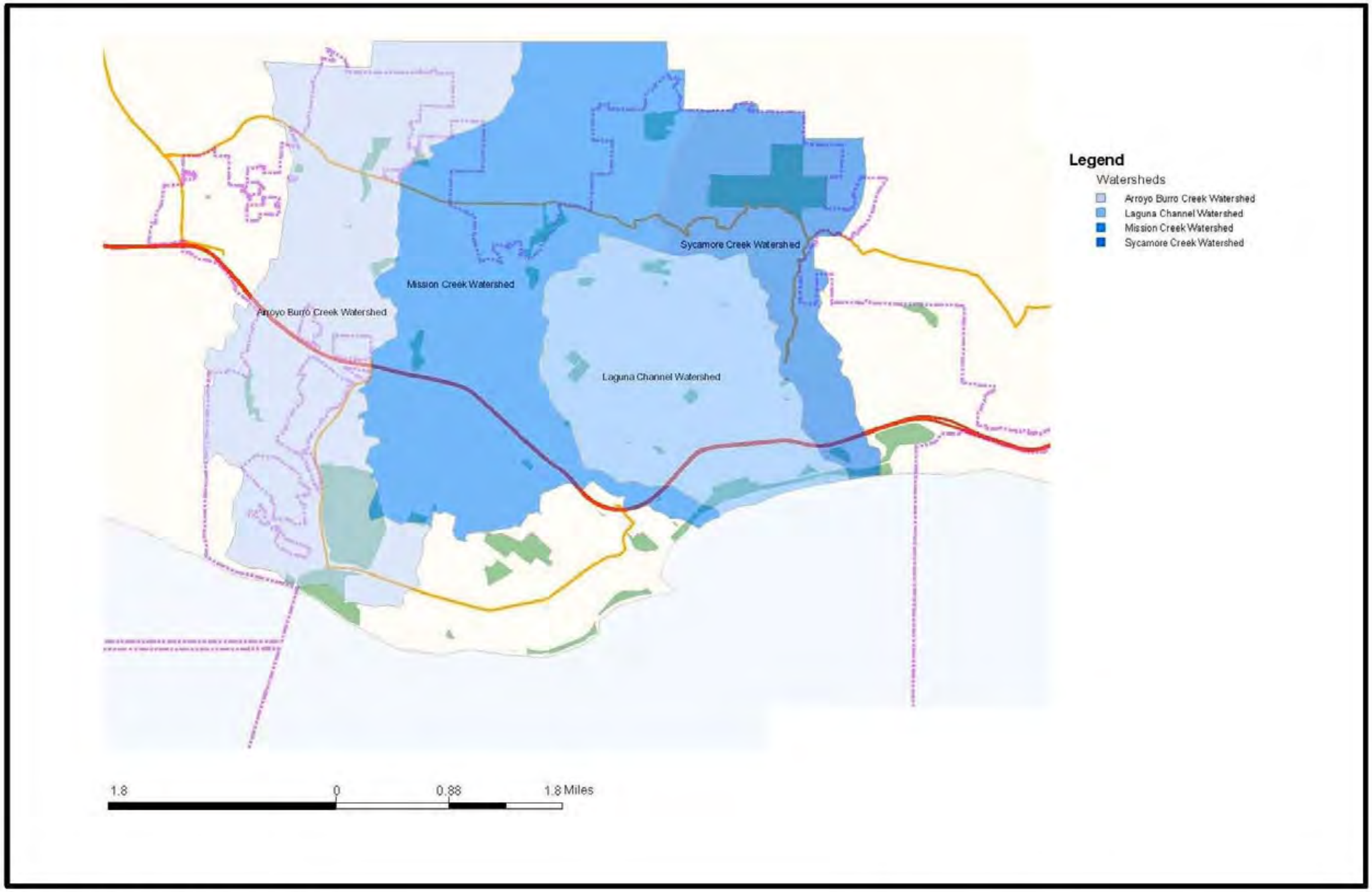


Figure 23

Source: City of Santa Barbara, 2013

City of Santa Barbara
General Plan
Santa Barbara Area Watersheds

Sycamore Creek. Sycamore Creek begins in the Los Padres National Forest and has five major tributaries: the main stem, which begins near the Sheffield Reservoir site; Parma Park tributaries; Coyote Creek; Westmont Creek and Chelham Creek. The tributaries converge near the intersection of Sycamore Canyon Road (SR 144) and Stanwood Drive (SR 192) where the creek enters the City. From there the creek continues southward through urbanized areas until it reaches the ocean at East Beach, east of the Cabrillo Pavilion Arts Center. The gradient of the lower portion of the creek is relatively level, making this area is subject to periodic flooding.

Laguna Channel. The Laguna Channel watershed includes major portions of the Downtown, Eastside and Waterfront areas of the City, and also includes the lower portions of the Riviera area. Much of the Laguna Channel watershed occupies the area of the historic estero that was located in the eastern portion of the Santa Barbara. The Laguna Channel is not a natural drainage. North of U.S. 101 the Laguna Channel consists of a series of underground reinforced concrete boxes and pipes. An open channel begins south of the highway and ends at the ocean near Chase Palm Park, where a tide gate is provided to prevent ocean water from entering the channel. Most of the Laguna Channel has a low to very low gradient, making the adjacent areas prone to flooding.

Other Drainages. Several smaller creeks are also located within the City of Santa Barbara. ***Cieneguitas Creek*** begins in the Santa Ynez Mountains and enters the western portion of the City near Cieneguitas Road and Foothill Road (SR 192). The creek flows to the southwest and converges with Atascadero Creek, which drains to the Goleta Slough. ***Arroyo Hondo Creek*** begins east of Carrillo Street in the Alta Mesa neighborhood and extends eastward to Leadbetter Beach. ***Lighthouse Creek*** begins south of Cliff Drive in the West Mesa neighborhood and drains to the ocean near the Coast Guard lighthouse and La Mesa Park.

Airport Area. The Santa Barbara Municipal Airport is located on low-lying ground within the historic boundaries of the Goleta Slough, and is also in an area where four major creeks are located: San Pedro, Tecolotito, Carneros and Las Vegas Creeks. The combined watershed area of the four creeks is approximately 30,000 acres or 64 square miles. The creeks on the Airport land typically have perennial flow due to tidal action and high groundwater discharge. The Airport property is very flat and is subject to periodic flooding.

Flood Hazard Zones in Santa Barbara

The Federal Emergency Management Agency (FEMA) has designated flood hazard zones throughout the City based on the results of studies that identify areas subject to inundation by a "base flood," which FEMA defines as a 100-year flood. The flood hazard areas, also known as Special Flood Hazard Areas, are depicted on Flood Insurance Rate Maps. Studies that are conducted to identify areas affected by a base flood evaluate a variety of flooding-related conditions and parameters, such as historic flooding; meteorological, hydrologic and hydraulic data; topography, open space and urban development conditions; and existing flood control structures and improvements. The flood hazard areas identified by Flood Insurance Rate Maps identify flood-prone areas based on the conditions at the time of the study, and do not consider the impacts of future development. The boundaries of designated flood hazard areas may be updated by FEMA from time to time to reflect changed conditions within the watershed or to correct a mapping error. Various map revision procedures are required by FEMA based on the reason and extent of the requested change to a Flood Insurance Rate Map.

Flooding in low-lying areas of the City located near the areas where creek or drainage channels discharge to the ocean can be increased when high tides coincide with intense rainfall events. The higher sea level conditions caused by high tides can slow the flow of water before it reaches the ocean, causing flood flows to back up into flood-prone areas located near the coast.

The designated 100-year flood zone areas in the City of Santa Barbara encompass 1,166 acres, or 9.7 percent of the City. Areas of the City that have been identified as being located within a 100-year floodplain are generally depicted on Figure 24 and are briefly described below. The Flood Insurance Rate Maps prepared by FEMA should be reviewed for more detailed information regarding the location of 100-year floodplain areas.

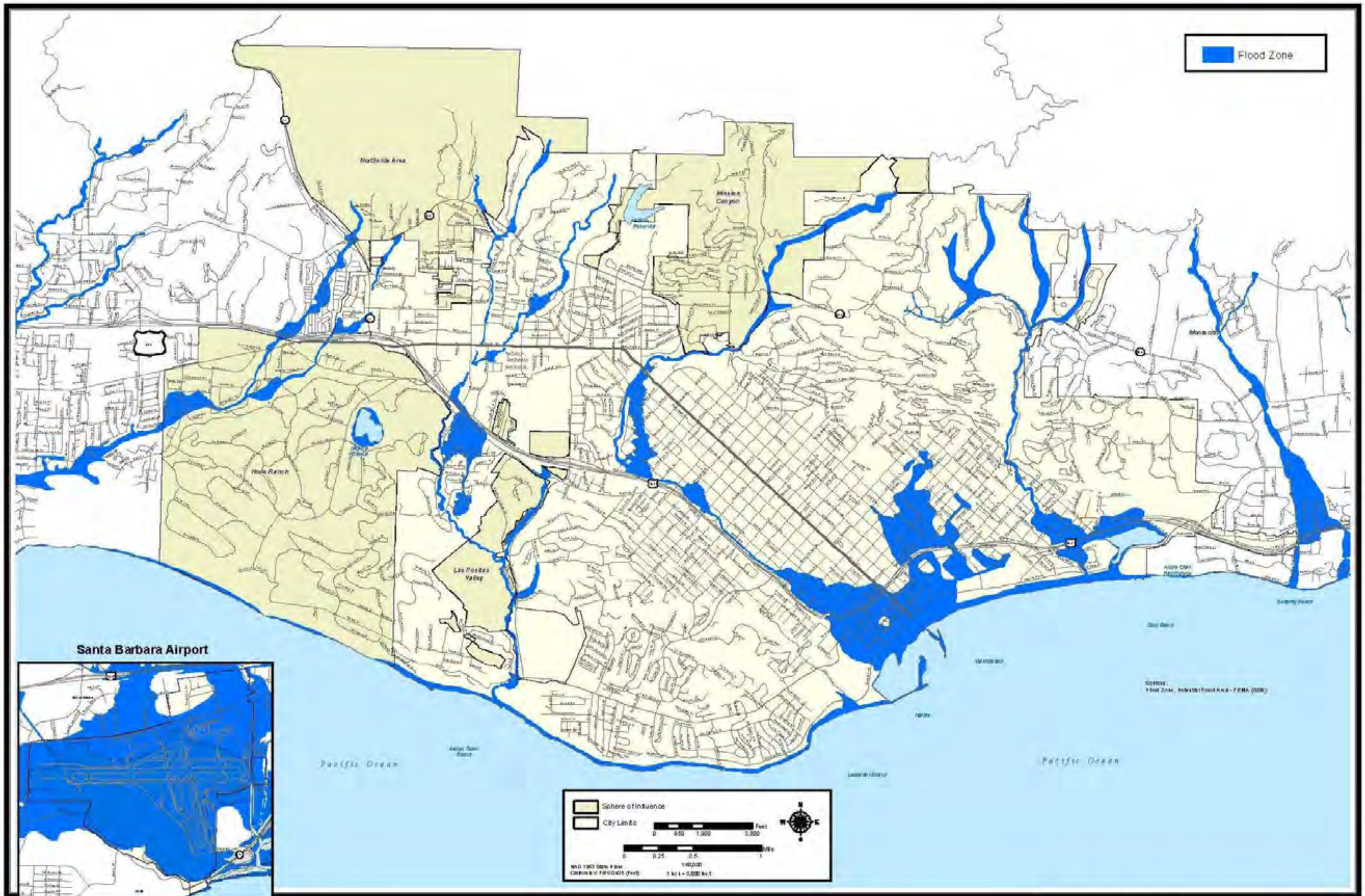
Arroyo Burro Creek. Floodwater from Arroyo Burro Creek during a 100-year storm may inundate an area located north of and adjacent to U.S. 101 in the southeastern portion of the Upper State neighborhood. On the south side of the highway, areas of the Hidden Valley neighborhood may also be flooded. Small areas in the San Roque and Hitchcock neighborhoods adjacent to San Roque Creek, a tributary to Arroyo Burro Creek, may also experience flooding-related impacts.

Mission Creek. Flood zones along the northern portions of Mission Creek are generally confined to the creek channel until the creek enters the Oak Park neighborhood, where 100-year flood zones have been designated along the western portion and in the southeastern area of the neighborhood. Along the lower reaches of the creek, flooding may affect areas located in the West Downtown, Lower State, West Beach and Waterfront neighborhoods. Floodwater from Mission Creek can also enter the Laguna Channel watershed, which adversely affects the ability of the Laguna Channel to convey flood flows.

Sycamore Creek. Runoff from a 100-year storm is generally contained within or adjacent to the Sycamore Creek channel until it reaches the Eastside neighborhood, where the southern portion of the neighborhood may experience flooding. Sycamore Creek can also cause flooding impacts in portions of the East Beach neighborhood, where overbank flows occur due to a reduction in the creek channel slope and the resulting reduction in channel conveyance capacity.

Laguna Channel. Flooding associated with the Laguna Channel during a 100-year storm can affect portions of the Lower State and Milpas neighborhoods, the western end of the East Beach neighborhood, and extensive areas of the Waterfront and Lower East neighborhoods.

Airport Area. Extensive areas located at and adjacent to the Airport may be inundated during a 100-year storm. The new airline terminal building is located within a 100-year floodplain, but outside of the designated boundaries of the floodway. The new terminal building was constructed in accordance with the requirements of the City's Floodplain Ordinance, which required the structure to be elevated to the 100-year flood water elevation.



City of Santa Barbara
General Plan
100-Year Floodplains

Figure 24

Structures That May be Affected by Flooding

Buildings and structures located within the flood hazard areas depicted by Flood Insurance Rate Maps and generally illustrated on Figure 24 may be affected by flooding resulting from a 100-year storm. As part of the Santa Barbara Annex to the *Multi-Jurisdictional Hazard Mitigation Plan,* a vulnerability assessment was conducted to identify City-owned facilities that could be adversely affected by flooding hazards resulting from a 100-year storm. The vulnerability assessment indicates that various Airport and Santa Barbra Harbor facilities, Stearns Wharf, the Public Works yard on Laguna Street, and Fire Station No. 2 on Cacique Street are located within designated flood hazard areas.

Storm and Flood Events in the Santa Barbara Area

Santa Barbara is frequently affected by large storms and damaging floods, and since 1862 at least 19 separate flooding events have caused damage in the City. On average, a damaging flood occurs in the City approximately once every eight years. Brief descriptions of some of the larger storm and flooding events that have affected the Santa Barbara area are provided below.

- Three storms that occurred between December 1861 and January 1862 are collectively referred to the Great Floods, and caused extensive damage throughout California. Sediment and debris from the Santa Ynez Mountains that was produced by the storms filled in the Goleta Slough, which before the storms was deep enough to accommodate large ships.
- Heavy rains started on January 15, 1914 and continued for two weeks, producing over 16 inches of rain. The storm resulted in the destruction of 12 homes and six bridges in the Mission Creek area.
- Storms in January 1952 inundated more than fifty homes around Mission Creek. The Santa Barbra County Flood Control District was created in response to the damage caused by these storms.
- Relatively light rains fell on areas burned by the Coyote fire in 1964, but due to the fire-related removal of vegetation form the watershed the rain caused severe flooding in creeks that flow through the Montecito area.
- Storms during January 1969 caused flooding damage throughout California, and flooded the Santa Barbra Airport.
- El Niño storms that occurred during the winter of 1982 and 1983 caused extensive damage throughout Southern California. A storm on March 2, 1983 generated wavest that caused extensive damage to Stearns Wharf, the Santa Barbara Harbor, and the Leadbetter Beach parking lot.
- Storms that occurred in January and March of 1995 caused extensive damage in Santa Barbara and surrounding areas. The January 10th storm damaged or flooded 510 structures on the South Coast, and temporarily closed U.S. 101, the Santa Barbara Airport and rail service through the area. The Airport was almost completely submerged and was closed for three days while mud and debris was removed from runways. The March 10th storm damaged many of the structures affected by the January storm, and once again closed the Airport. One fatality occurred in the Sycamore Creek area.
- Several large rainfall events in February 1998 dropped over 21 inches of rain on the Santa Barbara area. The storms closed the Airport and resulted in other disruptions to travel through the area.
- A powerful storm in January 2005 caused wide-spread damage throughout Southern California, including the La Conchita landslide that resulted in 10 fatalities and damaged or destroyed 31 homes.

Possible Effects of Climate Change on Stream Flooding

Although the effects of climate change may result in overall drier conditions and a decrease in average amounts of precipitation, it is expected that the number of intense rainfall events will increase. If large storms occur more frequently, a corresponding increase in the frequency and severity of stream flooding is likely to occur and more extensive areas could be affected by flooding.

In addition to an increase in storm intensity and frequency, flooding in coastal areas where streams meet the coast may be increased due to a rise in sea level. Estimates of future increases in the elevation of sea level vary considerably due to variations in assumptions regarding greenhouse gas emission control effectiveness and other factors. However, projections of future sea level rise provided by the Coastal and Ocean Working Group of the California Climate Action Team (2010) indicate that a five- to eight-inch rise in sea level over year 2000 conditions may occur by 2030; 10- to 17-inches of sea level rise may occur by 2050; and between 31 and 69 inches of sea level rise may occur by 2100. As ocean levels rise, backwater conditions may be created that slow the flow of floodwater as it drains to the ocean, resulting in increased upstream flooding of low-lying coastal areas.

A climate change-related an increase in temperatures and a reduction in average amounts of precipitation will have the potential to result in more frequent and severe wildfires. If fires result in more widespread removal of protective vegetation from watershed areas, stormwater runoff rates and volumes can be expected to increased, resulting in an increased potential for downstream flooding. In addition, the amount of sediment and debris generated by storms would also be increased, which can reduce the water carrying capacity of stream channels and flood control facilities. Increased sediment and debris volumes can also increase the "bulk" of floodwaters, which can contribute to an increase in the extent of areas affected by flooding.

Hazard Reduction

Numerous regulatory requirements and risk reduction programs have been implemented by federal, state and local agencies to minimize the effects of stream flooding. In general, these requirements include programs that reduce the potential for damage to structures and to provide and maintain flood control facilities. Some of the measures that reduce the risk and consequences of flooding in the City are briefly described below.

National Flood Insurance Program. The National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973 require FEMA to evaluate flood hazards, and in doing so FEMA prepares Flood Insurance Rate Maps that identify Special Flood Hazard Areas. The base flood is the regulatory standard used by the National Flood Insurance Program as the basis for requiring owners of structures located in Special Flood Hazard Areas to purchase and maintain flood insurance as a condition of receiving federal or federally related financial assistance, such as mortgage loans from federally insured lending institutions. The National Flood Insurance Program is required to offer federally subsidized flood insurance to property owners in communities that adopt and enforce floodplain management ordinances that meet minimum criteria established by FEMA.

Santa Barbara County Flood Control District. The Santa Barbara County Flood Control District has a wide range of responsibilities and provides services to the City of Santa Barbara. Services provided by the District include the operation and maintenance of the stream and drainage channels under the jurisdiction of the District, the construction, operation and maintenance of debris basins that retain rock, sand, mud and organic debris that can clog channels and diminish the effectiveness of downstream flood control facilities; emergency storm response, including providing information to the public, storm monitoring and floodflow forecasting; and post-storm rehabilitation of damaged flood control facilities.

City Storm Drain System. The stormwater conveyance system within the urbanized areas of the City includes structures such as streets, curbs, gutters, culverts, ditches, manmade channels, and below ground pipes that drain runoff to the City's creeks and major drainage channels. The purpose of the storm drain system is to carry runoff as quickly and efficiently as possible from developed areas to drainage facilities and eventually to the Pacific Ocean. The City Public Works Department, Street Division, operates and maintains the majority of the City's storm drain system, which includes activities such as: inspecting and repairing damaged facilities; cleaning and hauling away storm debris; responding during storm conditions to clear clogged drainage facilities; operation and maintenance of pump stations; and cleaning catch basin filters.

StormReady Designation. Santa Barbara has been designated as a StormReady® community, which is a planning and response program administered by NOAA through the National Weather Service. To be recognized as StormReady, communities must implement specified preparation criteria, including: have an emergency operations center capable of fulfilling specified functions; have multiple ways to receive National Weather Service warnings; have the capabilities to conduct or have access to specified meteorological monitoring systems; have one or more methods to provide storm-related information to the public; implement community preparedness measures and activities; and have and maintain an approved hazardous weather action plan.

City of Santa Barbara Development Requirements and Guidelines

Flood Plain Management Ordinance. Municipal Code Section 228.24, Flood Plain Management, provides requirements to minimize impacts that may result from development within floodplain areas. The objectives of the Ordinance include: protect human life and health; minimize expenditure of public money for repairs to flood control facilities; minimize damage to infrastructure; and ensure that potential buyers are notified that property is located in a flood hazard area.

Development Along Creeks Ordinance. Municipal Code Section 28.87.250, Development Along Creeks, provides requirements to minimize development-related impacts that may result from development adjacent to Mission Creek. The ordinance requirements apply to proposed development located within 25 feet of the top of the creek bank. The purpose of the requirements are to: prevent undue damage or destruction of developments by flood waters; prevent development on one parcel from causing undue detrimental impact on adjacent or downstream properties during a flood; and to protect the public health, safety and welfare.

Storm Water Management Plan. The goal of the City's Storm Water Management Plan is to protect the quality of water within the City to the maximum extent practicable. To achieve this goal, the Plan identifies strategies and guidelines related to the implementation of six stormwater management minimum control measures. Minimum Control Measure No. 5 addresses post-construction stormwater management and minimizing the rate and volume of stormwater discharges from a project site. This control measure includes requirements that post-development peak stormwater runoff discharge rates not exceed the estimated pre-development rate when the increased peak discharge rate has the potential to result in downstream erosion. To the extent feasible, new development and redevelopment is required to retain, at a minimum, the peak run-off differential from pre-and post-conditions for a 25-year storm. Through the implementation of this requirement, a project's contribution to downstream flooding impacts will be reduced to the maximum extent practicable.

Storm Water Best Management Practices Manual. The Storm Water Best Management Practices Manual provides methods to achieve the water quality protection and stormwater runoff reduction goals of the City's Storm Water Management Plan. These goals can be achieved through the use of a combination of site design and runoff control best management practices. New and redevelopment projects are encouraged to implement Low Impact Development strategies to reduce runoff volume and discharge rate, which can minimize a projects contribution to peak runoff flows and downstream flooding-related impacts.

DAM FAILURE

Description of the Hazard

A dam is an artificial barrier that has the ability to impound water for the purpose of storage or control of the water. Dam inundation is the flooding of lands due to the release of impounded water resulting from the failure or overtopping of a dam. Dams can fail for one or a combination of reasons, including: overtopping caused by floods that exceed the capacity of the dam; failure of materials used in construction of the dam; movement and/or failure of the foundation supporting the dam; inadequate maintenance; or deliberate acts of sabotage.

The severity of downstream effects resulting from a dam failure is related to the manner in which the dam fails. A breach of the dam would likely result in a flood wave that builds gradually to a peak, then declines until the water level in the reservoir recedes to an elevation below the breach or until the reservoir is empty. If a dam were to fail rapidly, a flood wave would be formed quickly and then be followed by a gradual decline in flood water. A catastrophic dam failure could inundate areas downstream, resulting flooding, loss of life and injury, property damage, erosion and sediment deposition.

Local Conditions

The Lauro Dam and Reservoir is located north of and adjacent to the City limits and adjacent to the Foothill neighborhood. It was constructed in 1952 by the Bureau of Reclamation as part of the Cachuma Project, and is part of the South Coast Conduit water distribution system that provides water for the City of Santa Barbara and other communities on the South Coast. The dam is owned by the Bureau and is operated by the Cachuma Operations and Maintenance Board.

Lauro Dam is an earth filled structure that impounds water from Diablo Creek, which has a 0.44 square mile watershed area. The dam is 137 feet in height and the reservoir capacity is about 590 acre-feet. When full, the reservoir has a surface of about 15.6 acres and a maximum depth of about 56 feet. The dam has a spillway pipe that discharges to San Roque Creek under emergency conditions.

During the excavation of the dam foundation a southeast-northwest trending fault zone was observed in the center of the excavation. The fault was not considered a potential hazard at that time, however, based on the results of subsequent studies, the Bureau of Reclamation concluded that movement along the fault had the potential to displace the foundation of the dam. The fault located beneath the dam is described as the Rocky Nook fault in the Regional and Local Faults subsection of the Introduction provided above. Due the identified fault hazard, the Bureau evaluated several dam strengthening alternatives with the objective of correcting seismic safety deficiencies of the dam to achieve an acceptable level of risk that protects the public and maintains the benefits of the dam and reservoir. Modifications to the dam were completed in 2007. The dam was modified to capture seepage that could result from movement of the fault and to channel the seepage in a controlled manner, allowing the reservoir to empty without the embankment failing and causing downstream flooding (Bureau of Reclamation, 2004).

The Santa Barbara Annex to the *Multi-Jurisdictional Hazard Mitigation Plan* includes a map that depicts areas downstream of the Lauro Reservoir that would have the potential to be inundated in the event of a dam failure. Water released from the reservoir could follow two routes. Released water could travel across the western portion of the East San Roque neighborhood and the eastern segment of the Upper State neighborhood before it enters the Mission Creek channel and then generally stay within the channel until it reaches the ocean. The other pathway would be across the southeastern corner of the San Roque neighborhood, across Upper State and portions of the Hitchcock and Hidden Valley neighborhoods before the water enters the Arroyo Burro Creek channel and generally stays within the channel until it reaches the ocean.

Hazard Reduction

The Bureau of Reclamation and other federal agencies, such as FEMA, have established extensive regulatory requirements and programs that require ongoing inspection and maintenance of federally-owned dams. With the continued implementation of existing programs, the risk of a catastrophic dam failure of the Lauro Dam and resulting effects in the City is very low. No additional hazard reduction measures are required to reduce the potential for or consequences of impacts related to dam failure inundation.

COASTAL FLOODING AND INUNDATION

The effects of high tides, storm waves and a rising sea level may occur individually or in combination, resulting in an increased potential for substantial damage to development and coastal resources located on or near the coastline. This section describes existing coastal flooding conditions that have occurred in Santa Barbara, and also describes how climate change-related effects may contribute to an increase in coastal flooding and inundation hazards.

Description of the Hazard

Coastal flooding refers to a temporary covering of areas on or near the coastline caused by stream flow, high tides, ocean storm conditions or a combination of those processes. For example, when large storms cause high stream flows during high tide conditions, the elevated ocean level can create a "backwater" effect that impedes the drainage of stream flow into the ocean. This can increase floodwater heights in both coastal and inland areas near the coast. The impacts of coastal flooding may be substantially increased in the future due to climate change-related effects such as a rise in sea level, an increase in the frequency and severity of large storms, or an increase in wave heights.

Coastal inundation refers a permanent covering of an area by ocean water. A climate change-related rise in sea level would be the source of new inundation-related impacts. Beach and adjacent low-lying areas would be the most susceptible to the effects of coastal inundation.

Local Conditions

Coastal Flooding. Coastal flooding in Santa Barbara has generally occurred as a result of storm surge (large, storm-generated ocean waves moving onshore) combined with high tide conditions. The destructive combination of waves and a high tide was demonstrated in 1983 when waves generated by a large El Niño storm eroded portions of the Leadbetter Beach parking lot, damaged the Santa Barbra Yacht Club building and the Harbormaster's office, damaged Stearns Wharf, and carried debris across Chase Palm Park and onto Cabrillo Boulevard.

Figure 25 depicts coastal areas of the City that could be flooded as a result of storm surge during a 100-year storm under existing sea level conditions. Coastal areas that would be expected to incur flooding-related damage include most beaches and adjacent areas as far inland as Shoreline Drive and Cabrillo Boulevard. Figure 25 also depicts areas that could be affected by coastal flooding caused by a 100-year storm plus the effects of a 55-inch increase in sea level. A 55-inch increase in sea level is near the high end of ocean level projections for conditions that could occur by the year 2100. Under these possible future conditions, the areas that could be affected by coastal flooding are located substantially further inland than under existing ocean level conditions, and include much of the East Beach, Lower East and Laguna neighborhoods. Future coastal flooding conditions at the Airport would also be expected to increase in terms of frequency and severity, with additional low-lying areas near the airport experiencing the effects of coastal flooding during large storms.

There is a level of uncertainty associated with predicting how sea level rise conditions will affect coastal and inland areas because it is not known how fast or how much sea level conditions will continue to change in the future. However, it is reasonable to expect that as sea level increases, impacts resulting from coastal flooding will also increase.

Coastal Inundation. The potential for City beaches and adjacent areas to be inundated as a result of a climate change-related increase in sea level will be controlled by factors such as the future rate and magnitude of sea level rise, and the width and elevation of the City's beaches. Projections regarding the possible magnitude of sea level rise vary substantially; however, the *City of Santa Barbara Sea Level Rise Vulnerability Study* (Griggs, 2012) concluded that over an intermediate time frame (to 2050) a projected 14-inch rise in sea level would have a low probability of resulting in a permanent loss of City beaches. If sea levels were to continue to rise, areas that would have formerly only been temporarily flooded or submerged during very high tides and/or large El Niño storms will gradually begin to be inundated permanently. Over a long-term period (to 2100), a 55-inch rise in sea level would substantially increase the probability of permanent beach and adjacent area inundation.

Hazard Reduction

Reducing possible coastal flooding and inundation impacts resulting from the effects of climate change will require the implementation of adaptation strategies. The *Santa Barbara Climate Action Plan* (2012) identifies a range of adaptation strategies for coastal flooding and inundation hazards. These strategies include: continuing to implement existing emergency preparedness and response programs; conduct more detailed and periodic mapping of areas susceptible to coastal flooding and inundation so that more accurate predictions of potential future effects can be made; implement public facility programs to make infrastructure less vulnerable to flooding and inundation impacts; and the implementation of land use policies that minimize potential exposures of structures to rising sea levels.

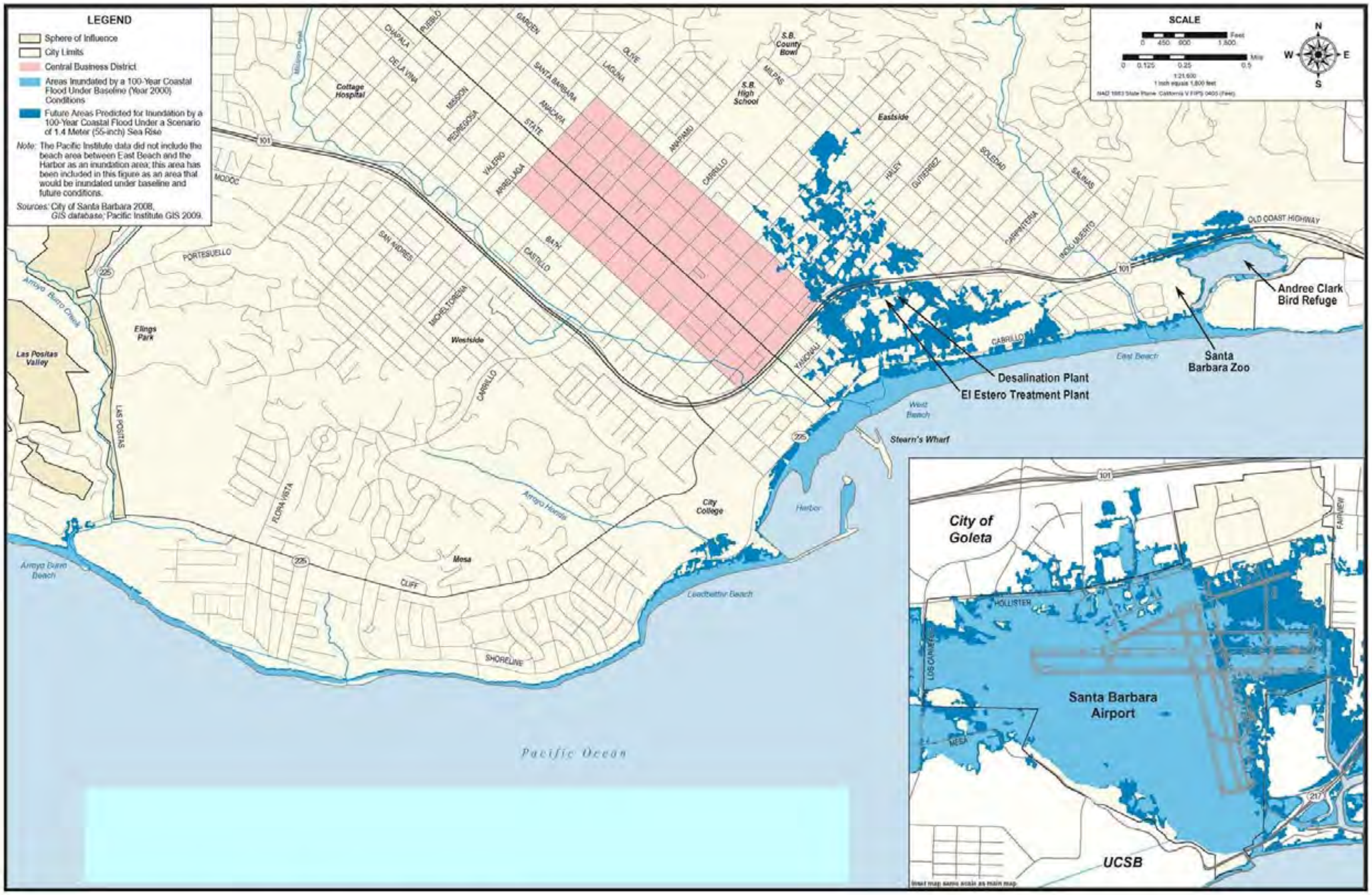


Figure 25

Source: Santa Barbara General Plan Update Program EIR, 2010

City of Santa Barbara
General Plan
Coastal Storm Surge

Hazardous Materials

INTRODUCTION

Chemical substances have many necessary and practical applications in our modern society, and are used extensively by manufacturing, commercial, agriculture uses, by institutions such as hospitals and schools, and by households. The benefits derived from the use of chemicals are substantial but due to their widespread use, accidental releases to the environment are likely to occur. When this happens, significant health, safety and environmental hazards can result. This section provides a brief overview of local programs that minimize the potential for adverse effects resulting from the use of hazardous materials. Potential issues associated with the transportation of hazardous materials through the Santa Barbara area are described in the Public Safety section.

Description of the Hazard

For this evaluation, a hazardous material is considered to be any substance that because of its quantity, concentration, physical or chemical characteristics poses a significant hazard to human health and safety or the environment in the event of an accidental or uncontrolled release. An extremely hazardous material is a substance that shows high acute or chronic toxicity, carcinogenity, bioaccumulative properties, is persistent in the environment, or is water reactive. A hazardous material may become a hazardous waste upon its abandonment, discard or recycling; or by actions that change the composition of previously non-hazardous material.

In addition to hazardous materials used by commercial, industrial and institutional uses, hazardous materials such as cleaners, paint, automotive and garden products, hobby supplies and swimming pool chemicals are used in substantial quantities in residential areas. The improper use or disposal of these types of hazardous materials has the potential to result in adverse health, safety and environmental consequences. An emerging health and safety issue is the improper disposal of pharmaceuticals, which when introduced into the environment can result in adverse human health and ecosystem impacts.

Soil and/or groundwater contamination are common consequences resulting from accidental releases of hazardous materials or waste. While there are many ways that hazardous substances can be released to the environment, leaking underground fuel tanks and releases from industrial land uses are common sources. Wastewater treatment plants are not intended to treat household hazardous wastes or pharmaceutical wastes, and the disposal of those substances to sewer systems can result in disruptions to the operation of the treatment plants and significant adverse impacts to the quality of treatment plant discharges.

Many federal and state regulatory programs have been enacted to protect water, air and land resources from the adverse effects of hazardous material releases. Regulatory programs also address the use, transportation and disposal of hazardous materials and waste; require that major hazardous material users/hazardous waste generators disclose those operations to the public; and ensure that releases to the environment are controlled and remediated in a manner that protects public safety.

Local Conditions

The Santa Barbara County Fire Department's Site Mitigation Unit and Leaking Underground Fuel Tank programs provide regulatory oversight of the assessment and remediation of hazardous material release sites in the City of Santa Barbara. The County Fire Department maintains a list of leaking underground fuel tank and other contamination sites located in the City. The areas with the highest concentration of contamination sites are generally located in the commercial and industrial areas of the Downtown, Eastside and Waterfront/Harbor areas, in the vicinity of Cottage Hospital; along Cliff Drive in the Mesa area; areas along Upper State Street; and at and near the Airport. The areas of the City where hazardous material release sites are most commonly located are depicted on Figure 26.

Several state agencies also provide information that is available to the public that identify sites with soil and groundwater contamination. The Hazardous Waste and Substances Sites List (Cortese List) is used by the state and local agencies to comply with CEQA requirements to provide information about the location of hazardous material release sites. This list is developed by the California Environmental Protection Agency, and information on the list is provided by the California Department of Toxic Substances Control (DTSC) and other state and local agencies. The California State Water Resources Control Board's GeoTracker program is a data management system that provides the location of and information about hazardous material release sites that have impacted groundwater.

Hazard Reduction

As indicated above, a variety of state and federal regulations have been enacted to protect public safety, minimize the risk of an accidental release, and to mitigate potential impacts when a release occurs. In general, these regulations pertain to all aspects of hazardous materials management, including material storage; handling and transportation; employee and public noticing; spill contingency planning; and emergency response measures. In California, the Unified Program consolidates, coordinates, and makes consistent the administrative requirements, permits, inspections, and enforcement activities of six environmental and emergency response programs:

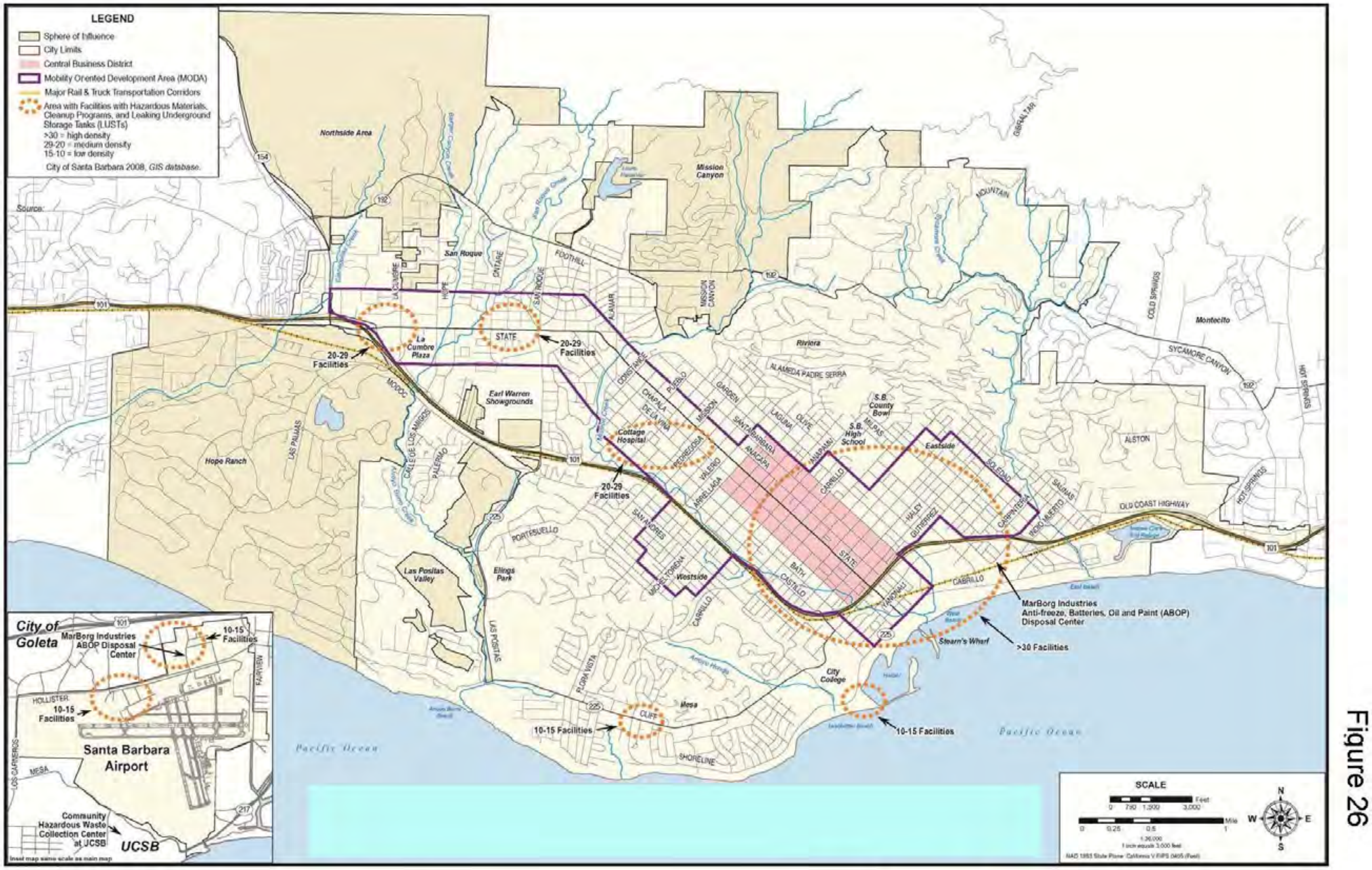
- Hazardous Materials Release Response Plans and Inventories (Business Plans)
- California Accidental Release Prevention (CalARP) Program
- Underground Storage Tank Program
- Aboveground Petroleum Storage Act (APSA) Program
- Hazardous Waste Generator and Onsite Hazardous Waste Treatment (tiered permitting) Programs
- California International Fire Code: Hazardous Material Management Plans and Hazardous Material Inventory Statements

The Unified Program is implemented at the local level by Certified Unified Program Agency (CUPA). In Santa Barbara County, the Hazardous Materials Unit of the Santa Barbara County Fire Department serves as the CUPA.

Business Plans. A regulatory program to minimize potential hazardous material-related hazards that is implemented on a local level is a requirement to prepare a Hazardous Material Business Plan. Business Plans are required whenever a business or facility handles, uses or stores a hazardous material or waste in quantities greater than or equal to threshold amounts (55 gallons for liquids, 200 cubic feet for gases, and 500 pounds of solids). Business Plans provide information that may be used by first responders to prevent or mitigate impacts to the public health and safety and to the environment resulting from a release or threatened release of a hazardous material. Business Plans are also used to satisfy federal and state Community Right-To-Know laws that require disclosure of hazardous material use characteristics to the public. A Business Plan must provide detailed information regarding the hazardous material inventory at a regulated facility; emergency response plans and procedure in the event of a reportable release or threatened release; and safety training for employees. Completed Business Plans are submitted to the CUPA and the local fire agency.

The City of Santa Barbra Fire Department is preparing to implement a geographical information system that will provide first responders with immediate access to hazardous material information provided by the Business Plans that have been prepared for regulated hazardous material use/storage sites in the City. Access to this information will substantially improve emergency response capabilities and protect the safety of first responders, the public and the environment. Household hazardous wastes and unused pharmaceuticals are commonly present in residences located throughout the community and have the potential to impact water quality, soil, human health, and ecosystems if not managed and disposed of properly. To avoid these potential consequences, it is important to provide adequate opportunities for the public to properly dispose hazardous and pharmaceutical wastes. Four household hazardous waste collection facilities are located at various locations throughout the Santa Barbara region and Santa Barbara Sheriff's stations will accept un-used pharmaceuticals. Providing additional opportunities and facilities for the safe collection of household hazardous wastes and pharmaceuticals would further reduce the potential for health, safety and environmental effects that may be associated with the improper disposal of those substances.

Integrated Pest Management. The use of pesticides, including insecticides, rodenticides, herbicides and fungicides, is another action that has the potential to result in the presence of hazardous materials in the environment. Pesticide residue, even in very low concentrations, can be toxic to aquatic organisms and result in health impacts to humans. The City of Santa Barbara adopted an Integrated Pest Management strategy in January 2004 to reduce the amount and toxicity of pesticides used on City property, and where feasible, to eliminate pesticide use in public areas. Integrated Pest Management is a set of principles developed to reduce or eliminate pesticide use while minimizing pest damage. The City's program has been implemented by all City departments, including the City Parks and Recreation Department, and has been shown to be effective at reducing pesticide use.



Source: Santa Barbara General Plan Update Program EIR, 2010

City of Santa Barbara
General Plan
Hazardous Material Release Areas

Public Safety

INTRODUCTION

Public safety issues addressed by this Safety Element include risk resulting from aircraft operations at the Santa Barbara Municipal Airport; the transportation of hazardous materials along local highways and rail lines through the City; the presence of natural gas transmission and distribution pipelines; and the creation of electromagnet fields by high voltage transmission lines.

AIRCRAFT OPERATIONS

Description of the Hazard

The Santa Barbara Municipal Airport is owned and operated by the City of Santa Barbara and is located in an incorporated area of the City, about eight miles west of the Downtown area of the City. The Airport property consists of 970 acres, including a 225-acre industrial and commercial area located along Hollister Avenue. The remaining airport area includes approximately 266 acres for airfield operations, 78 acres for aviation facilities and related businesses, and 430 acres within the Goleta Slough Ecological Reserve. A major runway safety improvement project and the redevelopment of the Airport's terminal building were completed in 2011 and 2012, respectively.

Airports can have beneficial economic and other effects on the communities around them, but can also result in impacts such as noise, vibration, odors, and the risk of accidents. Surrounding land uses can also adversely affect airport operations, particularly if development is allowed to encroach into the airspace used by approaching or departing aircraft. The *California Airport Land Use Planning Handbook* (2011) indicates that airport land use compatibility is the reconciliation of how land development and airports function together, and defines airport land use compatibility as follows: "*airport compatible land uses are defined as those uses that can coexist with a nearby airport without either constraining the safe and efficient operation of the airport or exposing people living or working nearby to unacceptable levels of noise or safety hazards. Compatibility concerns include any airport impact that adversely affects the livability of surrounding communities, as well as nay community characteristic that can adversely affect the viability of an airport.*"

To a large extent, land use compatibility is evaluated by determining the locations around an airport that have the greatest risk of experiencing an aircraft accident, and determining the risk of an accident occurring. Typically, accidents occur along the extended runway centerline (California, 2011). The implementation of safety and airspace protection measures minimizes the number of people at and away from the airport that are exposed to the risk associated with potential aircraft accidents and avoids flight hazards that interfere with aircraft navigation.

To assist in the evaluation of land use development and compatibility issues involving airports, in 1967 the California Legislature authorized the formation of Airport Land Use Commissions and the preparation of Airport Compatibility Land Use Plans. It is the objective of these planning programs to minimize the public's exposure to excessive noise and safety hazards while providing for the orderly expansion of airports. An *Airport Land Use Plan* for the public airports in Santa Barbara County was adopted in 1993 and is administered by the Santa Barbara County Association of Governments (SBCAG). SBCAG is in the process of preparing an update to the 1993 Airport Land Use Plan, and the Santa Barbara Airport is in the process of preparing a new Master Plan for the airport property.

Local Conditions

The Santa Barbara Airport is located within the historic boundaries of the Goleta Slough and land uses adjacent to the airport are predominately airport-related or open space. Other land uses have been developed in the vicinity of the Airport, including the University of California at Santa Barbara, and urban development located in the City of Goleta and unincorporated portions of the County of Santa Barbara. Future development within those areas have the potential to result in safety-related conflicts with airport operations.

The Santa Barbara Airport includes a primary east-west runway (Runway 7-25) and two parallel north-south runways (Runways 15-33, East and West). The Federal Aviation Administration and California have established airport and runway protection zones that are intended to minimize potential aircraft-related hazards. The existing airport/runway protection zones for the Santa Barbara Airport are depicted on Figure 27, and the types of land uses that may be compatible within each of the zones are summarized below. Please refer to the most-current Airport Land Use Plan for updated airport and runway safety zone designations and more detailed land use compatibility standards for each safety zone.

The **Runway Protection Zone** (RPZ) for the Santa Barbara Airport, which is also referred to as the "Clear Zone" by the City's Zoning Ordinance and the Airport Land Use Plan, is to be kept free of obstructions or distracting effects (e.g., flashing lights, sunlight reflection, glare, smoke, bird concentrations and electrical interference) that may affect aircraft operations. The *Santa Barbara Airport Land Use Plan* indicates that incompatible land uses in the RPZ include residential, commercial and industrial development, outdoor recreation facilities, and hazardous installations such as oil or gas storage.

The **Approach Zone** is an extension of the RPZ. As indicated by the Airport Land Use Plan, land uses that may be compatible within the Approach Zone include low density single-family dwellings; transportation and communication facilities; and specified manufacturing, warehouse, commercial, and recreation uses. Proposed land uses within the Approach Zone that would attract large concentrations of people are to be reviewed by the Airport Land Use Commission. "Large concentrations" of people are defined as being "on the order of 25 people per acre."

Land uses considered to be compatible with the **General Airport Traffic Pattern Zone** include residential, commercial, industrial and recreational uses. Proposed land uses within this zone that would attract large concentrations of people are to be reviewed by the Airport Land Use Commission.

Tall structures near airports have the potential to be hazardous to aircraft operations. Within the **Height Restriction Zone**, Part 77 of the Federal Aviation Regulations (FAR) establishes standards for determining when new development would result in an obstruction to navigable airspace. The regulations require that the FAA be notified of proposed construction or alteration of objects, whether permanent, temporary or of natural growth, if those objects would be of a height that exceeds FAR Part 77 criteria. The height limits are defined in terms of imaginary surfaces in the airspace that extend upward and outward from the airport runways.

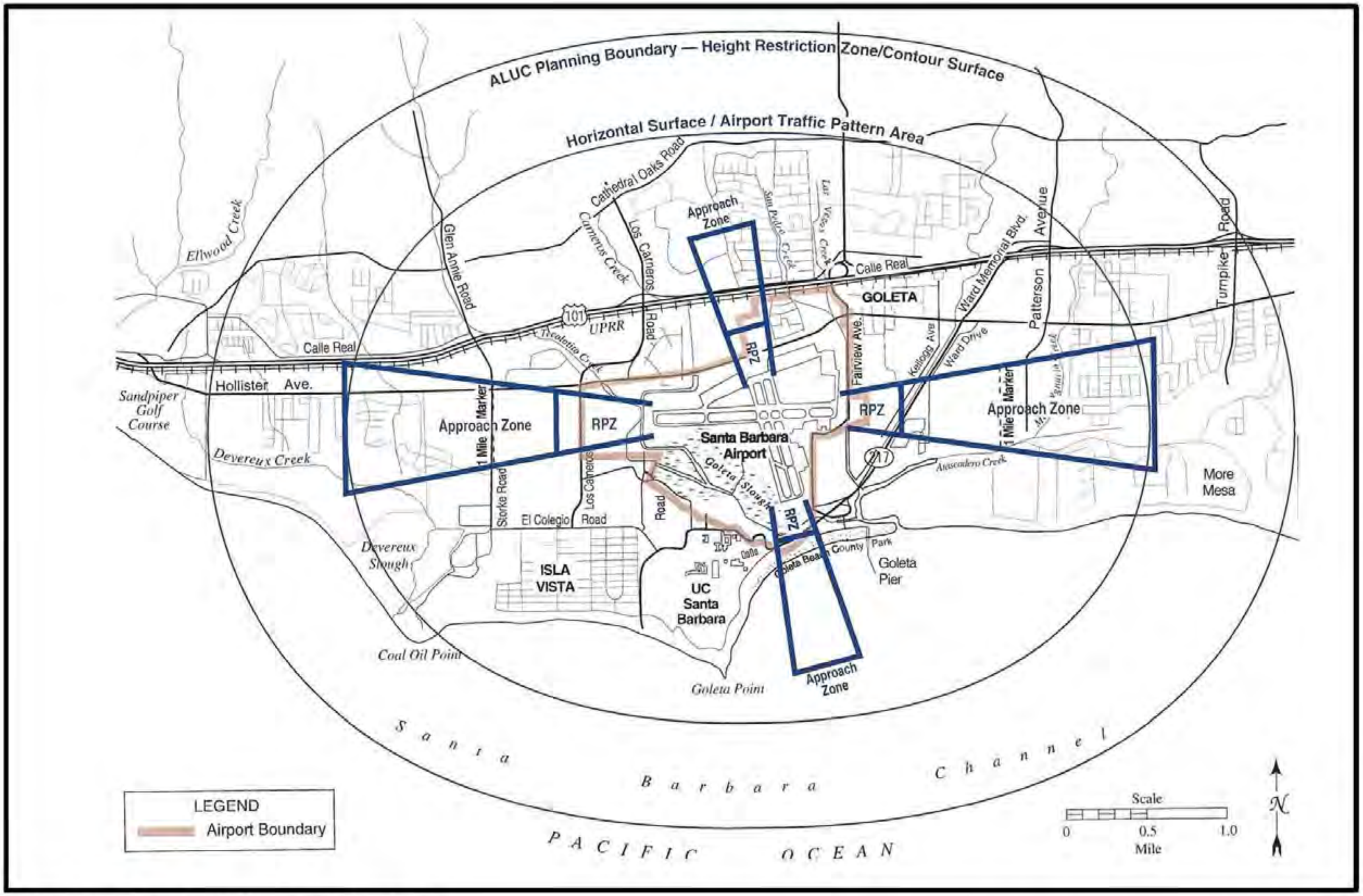


Figure 27

Source: Santa Barbara Airport Final EIS/R for the Aviation Facilities Plan

City of Santa Barbara
General Plan
Airport Protection Zones

Hazard Reduction

The type and intensity of future development that may occur on City property at and adjacent to the Airport is controlled by several land use planning programs, including the requirements of the Airport Zoning Ordinance, Title 29 of the Municipal Code; the *Airport Industrial Area Specific Plan; City of Santa Barbara Coastal Plan for the Airport and Goleta Slough,* and the *Aviation Facilities Plan.* In addition, future land uses on Airport property would be required to comply with the standards established by the most-current version of the *Airport Land Use Plan,* as well as FAA and other applicable regulations.

The potential for future development on properties located in the vicinity of the Airport to result in land use or safety conflicts would be minimized by complying with existing FAA regulations and reviewing projects to ensure that they are consistent with the land use planning objectives of the most-current *Airport Land Use Plan* and the *California Airport Land Use Planning Handbook.*

HAZARDOUS MATERIAL TRANSPORT

Description of the Hazard

An accidental release of hazardous materials or hazardous wastes at an industrial or commercial site, or the improper use and disposal of household hazardous waste in a residential area, has the potential result in adverse health, safety and/or environmental effects. Those hazards, however, are likely to be limited to the affected property and adjacent areas. The transportation of hazardous materials through Santa Barbara by vehicle or rail, has the potential to result in the creation of hazardous conditions that can affect a widespread area.

The potential for a spill or leak to occur while hazardous materials are being transported is very low, however, the consequences of such an event can be high. For example, the Association of American Railroads reports that each year, about 1.7 million carloads of hazardous materials are transported by rail in the United States, and in 2008, 99.998 percent of rail hazmat shipments reached their destination without a release caused by a train accident. However, in 1991 a train derailment near the community of Sea cliff in Ventura County caused the release of aqueous hydrazine, which is used to make agricultural, metal plating, plastics and photo processing chemicals; and the release of naphthalene, an industrial solvent. Both chemicals can be toxic if inhaled and their release caused the evacuation of approximately 300 residents and resulted in the closure of a 10-mile section of U.S. 101. Northbound and southbound traffic on the highway was rerouted to State Routes 166 and 33 while cleanup operations were underway.

Local Conditions

U.S. 101 and the Union Pacific Railroad extend through Santa Barbara from east to west and both are used for the transportation of hazardous materials. The City has limited control over the volume and type of materials transported along these corridors and it can be expected that various types of hazardous materials, including explosives, compressed and liquefied gasses, petroleum products, agricultural chemicals, industrial chemicals, military ordinance, radioactive material and hazardous wastes will pass through the City on a regular basis.

In the event of a hazardous material release, emergency response is provided by the California Highway Patrol, City Fire Department and the Santa Barbara County Fire Department, along with Caltrans and local Sheriff and Police Departments to provide containment, enforcement and traffic routing assistance. If necessary, the California Emergency Management Agency (Cal EMA) Hazardous Materials Section will coordinate the implementation of a hazardous material emergency response, and provide state and local managers with emergency coordination and technical assistance.

Another major transportation facility in the Santa Barbra area is SR 154, however, the transportation of hazardous waste is restricted along the portion of SR 154 that extends between the southern junction with U.S. 101 and the SR 246 intersection near Solvang. In addition, the California Assembly passed House Resolution HR 31 in 2012, which urges truck drivers traveling through Santa Barbara County to continue on State Highway Route 101 rather than using SR 154. The purpose of the resolution is to increase traffic safety along the highway, which will also minimize the potential for an accidental release of hazardous substances that could affect the water supply provided by Lake Cachuma.

Hazard Reduction

Numerous federal regulations have been enacted to manage the transportation of hazardous materials and waste, including the requirements of the Hazardous Materials Transportation Act, which is administered by the Department of Transportation and; and the requirements of the Resource Conservation and Recovery Act, which is administered by the Environmental Protection Agency. These and other regulations establish standards for labeling and manifesting hazardous waste; prescribe minimum safety standards and handling requirements; and require the implementation of appropriate material release response. State oversight of hazardous material transportation is also provided by numerous agencies, including California Highway Patrol requirements for carrier and driver licensing and safety; Department of Toxic Substances Control requirements pertaining to hazardous waste transportation; and Department of Motor Vehicles requirements for hazardous waste hauling vehicle registration and specialized driver certifications.

The Federal Railroad Administration is predominately responsible for rail safety in the U.S. and implements a variety of rail safety programs related to the transportation of hazardous materials, including track and rail car safety requirements. At the State level, the California Public Utilities Commission provides oversight for the transportation of hazardous materials by rail, and conducts inspections of hazardous material shippers.

NATURAL GAS PIPELINES

Description of the Hazard

Risks to the public from natural gas pipelines result from the potential for an unintentional release, which can impact surrounding populations, property, and the environment. These consequences may result from fires or explosions caused by ignition of the released gas, as well as possible toxicity and asphyxiation effects. Pipeline releases can occur due to a variety of causes, including internal and external corrosion, excavation damage, mechanical failure, operator error, and natural force damage (i.e., earthquakes).

The U.S. Department of Transportation, Pipeline & Hazardous Materials Safety Administration (PHMSA) provides data regarding the occurrence and consequences of natural gas pipeline-related incidents in the U.S. PHMSA reports that between 1992 and 2011, there have been a total of 124 “serious” incidents involving onshore natural gas pipelines, resulting in 43 fatalities and 209 injuries. “Serious” pipeline incidents are defined as an event involving a fatality or injury requiring in-patient hospitalization.

Although natural gas pipeline incidents are infrequent, they do have potentially significant consequences that may impact the general public. This was evidenced in 2010 in the City of San Bruno when a 30-inch natural gas transmission pipeline ruptured and the ensuing explosion and fire killed eight people, destroyed 37 homes, damaged 18 homes and resulted in numerous injuries.

Local Conditions

In the Santa Barbara area, the Southern California Gas Company is the natural gas utility company and operates a system of natural gas transmission and distribution lines that are generally located in the northern portion of the City, along the waterfront and on airport property. Transmission lines operated by the Gas Company generally operate at pressures above 200 pounds per square inch and transport gas from supply points to the gas distribution system. The distribution pipelines operate at pressures above 60 pounds per square inch and deliver gas in smaller volumes to the lower pressure distribution system.

Hazard Reduction

The federal government establishes minimum pipeline safety standards under the U.S. Code of Federal Regulations, Title 49, Parts 191 through 199. The Office of Pipeline Safety, with in the U.S. Department of Transportation PHMSA has overall regulatory responsibility for hazardous liquid and gas pipelines. Through certification by the Office of Pipeline Safety, California regulates, inspects and enforces intrastate gas pipeline safety requirements. These actions are implemented by the Office of the State Fire Marshal. In addition, the California Public Utilities Commission also has responsibilities regarding gas pipeline safety. On April 19, 2012, the Public Utilities Commission adopted a decision broadening the scope of its Natural Gas Safety Rulemaking and directed all California natural gas system operators to file natural gas system operator safety plans for their gas transmission and distribution facilities.

The Southern California Gas Company implements a pipeline safety program that includes measures such as: odorizing gas so leaks are more easily detectable; conducts leak surveys and pipeline patrols to identify missing pipeline markers, indicators of pipeline leaks, and construction activity that could damage a pipeline; interior and exterior pipeline corrosion control measures; and inspection and maintenance of valves, underground vaults, pipeline crossings, and pressure-relief devices.

Another important pipeline safety precaution is requirements to contact Underground Service Alert prior to initiating drilling or excavation activities so that the location of below ground utilities can be identified.

ELECTROMAGNETIC FIELDS

Description of the Hazard

The most common type of electricity used in the United States is alternating current (AC), where the current does not flow steadily in one direction but moves back and forth at a rate of 60 times per second. Wherever there is an electric current, there are also electric and magnetic fields, which are created by the electric charges. Electric fields are formed by the amount of the charge and magnetic fields result from the motion of the charge.

Electric fields are measured in terms of volts per meter (V/m) or kilovolts per meter (kV/m). Almost all household appliances create an electric field when plugged in, even when not in use. Magnetic field intensity is measured in units of gauss (rhymes with mouse) or milliGauss (mG). Another measurement unit for magnetic field levels is the microtesla (μT), where one microtesla equals 10 mG.

Electric and magnetic fields are created by high voltage electricity transmission lines, distribution lines that bring electricity in structures, wiring within households, and by common household appliances that use electricity. The strength of electric and magnetic fields produced by electrical lines and appliances diminishes quickly as the distance from the source of the field increases.

Electric and magnetic fields associated with the use of electricity differ from other types of electromagnetic energy such as x-rays and microwaves. For example, x-rays have so much energy that they can "ionize" or break up molecules and damage the DNA of cells. Microwaves are absorbed by water and can heat the water contained in living tissue. Because electric and magnetic frequency fields that are usually present in the environment do not ionize molecules or heat tissue, it was previously believed that they have no effect on biological systems. In the mid-1970's, however, a variety of studies demonstrated that biological changes can be produced by these weak fields.

More recent scientific research has focused on exposure to electromagnetic fields (EMF) rather than electric fields. Although some studies raised the possibility of emotional, behavioral, and reproduction effects, the greatest public concern regarding EMF exposure generally pertains to a statistical association between magnetic fields and cancer. Although the results of studies regarding this issue vary, most have concluded that there is insufficient data to conclude that there is a cause and effect relationship between EMF and cancer. The American Cancer Society provides the following information regarding the potential link between EMF and cancer:

> *Electric currents create extremely low-frequency (ELF) electromagnetic fields, which are at the low-energy end of the electromagnetic spectrum. We are all exposed to electromagnetic fields from the earth itself and from man-made sources. Examples of man-made sources include power lines, household wiring, and electrical appliances (when they are on).*
>
> *The possible link between electromagnetic fields and cancer has been a subject of controversy for several decades. Because we are all exposed to different amounts of these fields at different times, the issue has been difficult to study.*
>
> *One of the main concerns has been whether ELF affects the risk of childhood cancers such as leukemia and brain tumors. In the studies that have looked at a possible link with childhood leukemia, the results have been mixed. If there is an increased risk it is likely to be small, but a weak link cannot be ruled out entirely. Studies of other childhood cancers have generally not found any strong links to electromagnetic fields.*
>
> *Most studies in adults have not found links between electromagnetic fields and cancer.*
>
> *It's not clear exactly how electromagnetic fields, a form of low-energy, non-ionizing radiation, could increase cancer risk. Studies of lab animals have generally not found that magnetic fields increase the risk of cancer. The absence of a link in animal studies makes it less likely that human exposure to electromagnetic fields, at home or at work, affects cancer risk.*
>
> *The National Institute of Environmental Health Sciences (NIEHS) describes the scientific evidence suggesting that electromagnetic field exposures pose a health risk as "weak". But because a possible increase in cancer risk can't be ruled out completely, the NIEHS has advised that people concerned about EMF exposure may want to consider practical ways to reduce their exposure, such as finding out where their major EMF sources are and limiting the time spent near them. There are more costly actions, such as burying power lines or moving out of a home, that might also lower EMF exposure. But because scientists aren't sure if EMF poses any health hazards, it's not clear if such actions are warranted, according to the NIEHS.*

Local Conditions

Southern California Edison (SCE) provides electrical service to the City. The transmission system in the City includes several large tower-mounted 66 kilovolt (kV) lines extending east to west along the base of the Santa Ynez Mountains, approximately two miles north of the City. The electrical distribution system operates at 2.4 kV, 4.16 kV and 16.5 kV and is distributed as needed throughout the City. Approximately 30 percent of the City's distribution system is underground.

SCE reports that that according to the NIEHS, magnetic fields under main feeder distribution lines or above underground lines can create fields around 10 to 20 mG. For smaller distribution lines, field levels are often below 10 mG to under 1 mG. At a distance of 100 feet, the magnetic field levels from distribution lines often drop to values similar to levels found in most homes.

Hazard Reduction

There are no federal or California numerical thresholds for exposure to electromagnetic fields. In 2006, the California Public Utility Commission determined that it is appropriate for utilities to continue to take no-cost or low-cost measures where feasible to reduce EMF exposure from new or upgraded utilities (CPUC Decision D.06-01-042). These types of actions may include design changes to utility systems, routing lines to limit exposures to areas of concentrated population and group facilities such as schools and hospitals, installing taller distribution line support structures, widening right of way corridors, and the burial of distribution lines.

Limiting EMF exposure may be achieved by implementing a practice referred to as "prudent avoidance." Prudent avoidance is a principle of risk management indicating that reasonable efforts to minimize potential risk should be taken when the actual magnitude of the risk is unknown. For individuals, this may be achieved by increasing the distance between yourself and appliances and/or minimizing time you use appliances at home or work. For jurisdictions, this could entail the implementation of no-cost and low-cost project design measures similar to those described above.

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PREPARERS

This Safety Element was prepared by Rodriguez Consulting, Inc., under contract to the City of Santa Barbara. Assistance in the evaluation of geologic hazards was provided by Campbell Geo, Inc.

Appendix B
Establishing Development Setbacks from Coastal Bluffs

CALIFORNIA COASTAL COMMISSION
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W11.5

MEMORANDUM

Date: 16 January 2003

To: Commissioners and Interested Parties

From: Mark Johnsson, Staff Geologist

Subject: **Establishing development setbacks from coastal bluffs**

STAFF NOTE

Consistency with section 30253 of the Coastal Act requires that:

> New development shall:
>
> (1) Minimize risks to life and property in areas of high geologic, flood, and fire hazard.
>
> (2) Assure stability and structural integrity, and neither create nor contribute significantly to erosion, geologic instability, or destruction of the site or surrounding area or in any way require the construction of protective devices that would substantially alter natural landforms along bluffs and cliffs.
>
> ...

This section requires that new development be located such that it will not be subject to erosion or stability hazard over the course of its design life. Further, the last clause requires the finding that no seawall, revetment, jetty, groin, retaining wall, or other shoreline protective structure, inasmuch as such a structure would substantially alter natural landforms along bluffs and cliffs, will be needed to protect the development over the course of its design life. The Commission has found on many occasions that siting new development away from eroding bluffs is the preferred means of assuring consistency with this section, and the establishment of bluff-top setbacks for new development is an integral part of most local coastal programs. Further, the State's draft Policy on Coastal Erosion Planning and Response states that avoidance of geologic hazards, such as eroding coastal bluffs, should be the primary means of safeguarding new development.

Accordingly, the determination of what constitutes an adequate setback is a critical component of the analysis of proposals for new development.

Because coastal bluffs are dynamic, evolving landforms, establishing appropriate development setbacks from coastal bluffs is far more challenging than it is for manufactured or natural slopes not subject to erosion at the base of the slope. The mechanisms of coastal bluff retreat are complex, but can be grouped into two broad categories. Bluff retreat may occur suddenly and catastrophically through slope failure involving the entire bluff, or more gradually through grain-by-grain erosion by marine, subaerial, and ground water processes. For both processes, the setback must be adequate to assure safety over the design life of the development.

In an effort to clarify the analytical procedures undertaken by Coastal Commission staff in evaluating proposed development setbacks, the Commission's staff geologist made two presentations at the *California and the World Ocean '02* conference held in Santa Barbara in October 2002. These presentations were combined into a single manuscript to be published in the proceedings volume for that Conference, which is attached to this staff report.

In order to bring these procedures before the Commission, and to further the exposure of them to the public, the staff geologist will brief the Commission on this methodology at the February 2003 hearing. This methodology does not represent a formal policy or position of the Coastal Commission. In fact, there may be other appropriate methodologies to establish development setbacks, and the Commission has the discretion to base a decision on any method that it finds technically and legally valid. Further, as new techniques and information become available, these methodologies may change. Nevertheless, the type of analysis outlined here represents the current analytical process carried out by Coastal Commission staff in evaluating proposals for new development on the California coast, and in recommending action upon those proposals to the Commission. The Commission then makes its decisions on a case-by-case basis, based upon the site-specific evidence related to the particular development proposal.

Attachment: Preprint of manuscript entitled "Establishing development setbacks from coastal bluffs," by Mark J. Johnsson, to appear in *Proceedings, California and the World Ocean, '02*, Orville Magoon, ed., 21 p.

Johnsson, Mark J., *in press*, Establishing Development Setbacks from Coastal Bluffs, *in* Magoon, Orville (ed.) *Proceedings, California and the World Ocean '02.*

Establishing Development Setbacks from Coastal Bluffs

Mark J. Johnsson[1]

Abstract

Responsible development, and California law, requires that coastal development be sited a sufficient distance landward of coastal bluffs that it will neither be endangered by erosion nor lead to the construction of protective coastal armoring. In order to assure that this is the case, a development setback line must be established that places the proposed structures a sufficient distance from unstable or marginally stable bluffs to assure their safety, and that takes into account bluff retreat over the life of the structures, thus assuring the stability of the structures over their design life. The goal is to assure that by the time the bluff retreats sufficiently to threaten the development, the structures themselves are obsolete. Replacement development can then be appropriately sited behind a new setback line. Uncertainty in the analysis should be considered, as should potential changes in the rate of bluff retreat and in slope stability. The deterministic approach presented here is based on established geologic and engineering principals, and similar approaches have been used to establish development setbacks from slope edges throughout the world for some time. Alternative approaches based on probabilistic methods may allow, however, for better quantification of uncertainties in the analysis. Although probabilistic coastal hazard assessment is in its infancy and data needs are large, the approach shows great promise. Developing probabilistic methods for establishing development setbacks should be a goal for future coastal zone management in California.

Introduction

In an era of sea-level rise such as has persisted on Earth for the past ~20,000 years (Curray 1965; Emery and Garrison 1967; Milliman and Emery 1968), the landward recession of coastal bluffs is an inevitable natural process wherever tectonic or isostatic uplift rates are lower than the rate of sea-level rise. New structures should be sited a sufficient distance landward of coastal bluffs that they will neither be endangered by erosion nor require the construction of coastal armoring to protect them from erosion over their design life. Because coastal bluffs are dynamic, evolving landforms, establishing responsible development setbacks from coastal bluffs is far more challenging than it is for manufactured or natural slopes not subject to erosion at the base of slope. Although internationally agreed-upon methods for establishing setbacks from static slopes have been developed, and codified in the International Building Code, no such consensus has emerged with respect to setbacks from dynamic slopes such as coastal bluffs. This paper presents a methodology for establishing such setbacks given the types of data generally available through relatively inexpensive geologic studies.

Relatively little work has been undertaken towards developing rational methodologies for establishing development setbacks from bluffs and cliffs. Coastal development setbacks have generally focused primarily on beach erosion, rather than on coastal bluff recession (*e.g.*, Healy 2002). Generally, the approach has been to simply

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extrapolate historic long-term erosion rates into the future, and establish setbacks at a particular predicted future shoreline position. This approach does not work well for shorelines with coastal bluffs, where the setback also must consider the possibility of bluff collapse (see Priest 1999 for a discussion of these issues). Komar and others (2002) presented a methodology for establishing setbacks for use on coasts where the principal hazards are wave runup and storm surge. They showed how their method could be extended to use on coasts with sea cliffs by determining the average number of hours that a sea cliff would be subject to wave attack. Their method does not, however, include a quantitative assessment of bluff stability. Given the significance of the coastal erosion threat in California, where public safety, financial investments, and environmental resources are at stake, and given the call for action urged by such recent national studies as the Heinz Center's FEMA-sponsored studies (The Heinz Center 2000a; 2000b), it is critical that a rational method be established for establishing development setbacks on coastal bluff tops.

The California Coastal Act (California Public Resource Code Sections 30000 *et seq.*) regulates coastal development in California. Section 30253 states, in part, that:

> New development shall:
>
> (1) Minimize risks to life and property in areas of high geologic, flood, and fire hazard.
>
> (2) Assure stability and structural integrity, and neither create nor contribute significantly to erosion, geologic instability, or destruction of the site or surrounding area or in any way require the construction of protective devices that would substantially alter natural landforms along bluffs and cliffs.
>
> ...

This law requires that new development be sited in such a way that it will not be subject to erosion or stability hazard over the course of its design life. Further, the last clause requires the finding that no seawall, revetment, jetty, groin, retaining wall, or other shoreline protective structure will be needed to protect the development over the course of its design life.

The principal challenge in meeting these requirements is predicting the amount and timing of coastal erosion to be expected at a particular site. The landward retreat of coastal bluffs is far from uniform in space or time (Komar 2000). Marine erosion tends to be concentrated at points and headlands due to wave refraction, occurs more quickly in weak rocks, and may vary along a coastline as these and other factors vary (Honeycutt et al. 2002). Further, coastal bluff retreat tends to be temporally episodic due to a variety of external and internal factors.

The mechanisms of coastal bluff retreat are complex (Emery and Kuhn 1982; Sunamura 1983; Vallejo 2002), but can be grouped into two broad categories. Bluff retreat may occur suddenly and catastrophically through slope failure involving the entire bluff, or more gradually through grain-by-grain erosion by marine, subaerial, and ground water processes. The distinction between the two categories may be blurred in some cases—"grains" may consist of relatively large blocks of rock or shallow slumps, for example. Nevertheless, in establishing structural setbacks it is important to evaluate the susceptibility of the bluff to both catastrophic collapse and to more gradual erosion and retreat.

For both slope stability and long-term bluff retreat by "grain-by-grain" erosion, the setback must be adequate to assure safety over the design life of the development. For this reason, it is necessary to specify the design life of the structure. Many Local Coastal Programs (the implementation of the California Coastal Act at the local government level) specify a particular value, although the Coastal Act itself does not. The most commonly assumed design lives for new development range from 50 to 100 years; the most common value is 75 years. The reasoning behind establishing a setback based on the design life is that by the time the bluff retreats sufficiently to threaten the structure, the structure is obsolete and is ready to be demolished for reasons other than encroaching erosion. Replacement development can then be appropriately sited at a new setback, appropriate for conditions at the time of its construction. This process may be thwarted by limitations imposed by parcel size, and Constitutional takings issues may complicate land use decisions. Nevertheless, the only alternative to an armored coast—with all of its attendant impacts—is to continually site, and reposition, development in harmony with coastal erosion as it inevitably moves the shoreline landward.

What follows is the methodology employed by the staff of the California Coastal Commission in evaluating setbacks for bluff top development. I would suggest that this methodology is useful on other coasts with coastal bluffs, as well. This methodology does not represent a formal policy or position of the Coastal Commission. In fact, there may be other appropriate methodologies to establish development setbacks, and the Commission has the discretion to base a decision on any method that it finds technically and legally valid. Any such alternative methods should, however, be at least as protective of coastal zone resources as those outlined here. Further, as new techniques and information become available, these methodologies may change. Nevertheless, the type of analysis outlined here represents the current analytical process carried out by Coastal Commission staff in evaluating proposals for new development on the California coast, and in recommending action upon those proposals to the Commission. The Commission then makes its decisions on a case-by-case basis, based upon the site-specific evidence related to the particular development proposal.

Definition of "Bluff Edge"

Development setbacks normally are measured from the upper edge of the bluff top. Accordingly, a great deal of effort often is focused on defining that "bluff edge." The bluff edge is simply the line of intersection between the steeply sloping bluff face and the flat or more gently sloping bluff top. Defining this line can be complicated, however, by the presence of irregularities in the bluff edge, a rounded or stepped bluff edge, a sloping bluff top, or previous grading or development near the bluff edge. Accordingly, a set of standards for defining the bluff edge is necessary.

Under the California Coastal Act, the bluff edge is defined as:

> … the upper termination of a bluff, cliff, or seacliff. In cases where the top edge of the cliff is rounded away from the face of the cliff as a result of erosional processes related to the presence of the steep cliff face, the bluff line or edge shall be defined as that point nearest the cliff beyond which the downward gradient of the surface increases more or less continuously until it reaches the general gradient of the cliff. In a case where there is a steplike feature at the top of the cliff face, the landward edge of the topmost riser shall be taken to be the cliff edge…" (California Code of Regulations, Title 14, §13577 (h) (2).

This definition is largely qualitative, and the interpretation of the topographic profile to yield a bluff edge determination at any given coastal bluff may be subject to various interpretations. Accordingly, it may be useful to use more quantitative means to define "bluff edge." One approach, adopted, for example, by the City of Laguna Beach, is to define the bluff edge as that point at which the coastal bluff attains a certain specified steepness. This steepness is equivalent to the first derivative of the topographic profile. Such a definition may, however, be inconsistent with the legal definition above. Further, ambiguous results may be obtained when the upper portion of the bluff fluctuates around the specified steepness value. Better results may be obtained by finding the point at which the second derivative, the rate of change in steepness, of the topographic profile increases sharply. This approach may be amenable to computer analysis, although such analysis is rarely employed.

The position of the bluff edge may be changed by a variety of processes, natural and anthropogenic. Most obvious is the landward retreat of the bluff edge through coastal erosion. A bluff edge also may move seaward, through tectonic processes, but such movement is rare and usually small on human time scales. More significant is the anthropogenic modification of the bluff edge by grading or the construction of structures. A landward shift of the bluff edge commonly occurs through cutting into and removing natural materials during grading operations or the construction of seawalls. Conversely, placing artificial fill on or near the bluff edge generally does not alter the position of the natural bluff edge; the natural bluff edge still exists, buried beneath fill, and the natural bluff edge is used for purposes of defining development setbacks.

Slope Stability

Once the bluff edge is located, the first aspect to consider in establishing development setbacks from the bluff edge is to determine whether the existing coastal bluff meets minimum requirements for slope stability. If the answer to this question is "yes," then no setback is necessary for slope stability considerations. If the answer is "no," then the distance from the bluff edge to a position where sufficient stability exists to assure safety must be found. In other words, we must determine how far back from the unstable or marginally slope must development be sited to assure its safety.

We are guided in this analysis by the industry-accepted standards for artificial slopes (codified in many local grading ordinances), which require that a particular minimum "factor of safety" against landsliding be attained. A more difficult situation is the case of overhanging or notched coastal bluffs, or bluffs undermined by sea caves.

Landslides. Assessing the stability of slopes against landsliding is undertaken through a quantitative slope stability analysis. In such an analysis, the forces resisting a potential landslide are first determined. These are essentially the strength of the rocks or soils making up the bluff. Next, the forces driving a potential landslide are determined. These forces are the weight of the rocks as projected along a potential slide surface. The resisting forces are divided by the driving forces to determine the "factor of safety." A value below 1.0 is theoretically impossible, as the slope would have failed already. A value of 1.0 indicates that failure is imminent. Factors of safety at increasing values above 1.0 lend increasing confidence in the stability of the slope. The industry-standard for new development is a factor of safety of 1.5, and many b-cal grading ordinances in California and elsewhere (including the County of Los Angeles, and the Cities of Irvine, Malibu, and Saratoga, among others) require that artificial slopes meet this factor of safety.

A slope stability analysis is performed by testing hundreds of potential sliding surfaces. The surface with the minimum factor of safety will be the one on which failure is most likely to occur. Generally, as one moves back from the top edge of a slope, the factor of safety against landsliding increases. Therefore, to establish a safe setback for slope stability from the edge of a coastal bluff, one needs to find the distance from the bluff edge at which the factor of safety is equal to 1.5.

Inherent in the calculation of a slope stability analysis is the shape (topographic profile) and geologic makeup of the coastal bluff. There are many ways to calculate the forces involved in slope stability analyses. All methods must consider such factors as rock or soil strength, variations in rock and soil strength values due to different types of materials making up the slope, anisotropy in these values, and any weak planes or surfaces that may exist in the slope (Abramson et al. 1995). More subtly, other factors that must be considered include: pore water pressure, which produces a buoyant force that reduces the resisting forces, the particular failure mechanism that is most likely (*e.g.*, a block slide mechanism vs a circular failure mechanism), and seismic forces. Seismic forces normally are considered through a separate analysis, in which a force equal to 15% of the force of gravity is added to the driving forces. Because seismic driving forces are of short duration, a factor of safety of 1.1 generally is considered adequate to assure stability during an earthquake. This type of analysis is fairly crude, and other methods for evaluating slope stability based on maximum permanent displacement experienced during earthquakes do exist, but the pseudo-static method represents the current standard of practice for most development in California (Geotechnical Group of the Los Angeles Section of the American Society of Civil Engineers 2002). Guidelines for conducting slope stability analyses for review by the California Coastal Commission are presented in Table 1.

Table 1. Guidelines for performing quantitative slope stability analyses

1) The analyses should demonstrate a factor of safety greater than or equal to 1.5 for the static condition and greater than or equal to 1.1 for the seismic condition. Seismic analyses may be performed by the pseudostatic method or by displacement methods, but in any case should demonstrate a permanent displacement of less than 50 mm.

2) Slope stability analyses should be undertaken through cross-sections modeling worst case geologic and slope gradient conditions. Analyses should include postulated failure surfaces such that both the overall stability of the slope and the stability of the surficial units is examined.

3) The effects of earthquakes on slope stability (seismic stability) may be addressed through pseudostatic slope analyses assuming a horizontal seismic coefficient of 0.15g. Alternative (displacement) methods may be useful, but should be in conformance with the guidelines published by the Geotechnical Group, American Society of Civil Engineers, Los Angeles Section (2002).

4) All slope analyses should ideally be performed using shear strength parameters (friction angle and cohesion), and unit weights determined from relatively undisturbed samples collected at the site. The choice of shear strength parameters should be supported by direct shear tests, triaxial shear test, or literature references, and should be in conformance with the guidelines published by the Geotechnical Group, American Society of Civil Engineers, Los Angeles Section (2002).

5) All slope stability analyses should be undertaken with water table or potentiometric surfaces for the highest potential ground water conditions.

6) If anisotropic conditions are assumed for any geologic unit, strike and dip of weakness planes should be provided, and shear strength parameters for each orientation should be supported by reference to pertinent direct sheer tests, triaxial shear test, or literature references.

7) When planes of weakness are oriented normal to the slope or dip into the slope, or when the strength of materials is considered homogenous, circular failure surfaces should be sought through a search routine to analyze the factor of safety along postulated critical failure surfaces. In general, methods that satisfy both force and moment equilibrium, such as Spencer's (Spencer 1967; 1973), Morgenstern-Price (Morgenstern and Price 1965), and General Limit Equilibrium (Fredlund et al. 1981; Chugh 1986) are preferred. Methods based on moment equilibrium alone, such as Simplified Bishop's Method (Bishop 1955) also are acceptable. In general, methods that solve only for force equilibrium, such as Janbu's method (Janbu 1973) are discouraged due to their sensitivity to the ratio of normal to shear forces between slices (Abramson et al. 1995).

8) If anisotropic conditions are assumed for units containing critical failure surfaces determined above, and when planes of weakness are inclined at angles ranging from nearly parallel to the slope to dipping out of slope, factors of safety for translational failure surfaces should also be calculated. The use of a block failure model should be supported by geologic evidence for anisotropy in rock or soil strength. Shear strength parameters for such weak surfaces should be supported through direct shear tests, triaxial shear test, or literature references.

Establishing a safe setback line. Once the stability of the coastal bluff has been assessed, the development setback line to assure safety from marginally stable slopes is simply the line corresponding to a factor of safety of 1.5 (static) or 1.1 (pseudostatic), whichever is further landward. In establishing this line one can either use a single cross section and specify a single distance from the bluff edge at which the factor of safety rises to 1.5 (or 1.1 for the pseudostatic case), or use several cross sections and contour the factors of safety on the bluff top. Then, by choosing the 1.5 contour (or 1.1 for the pseudostatic case, if it lies further landward), a setback line is established. The latter method generally is necessary for large or complicated sites.

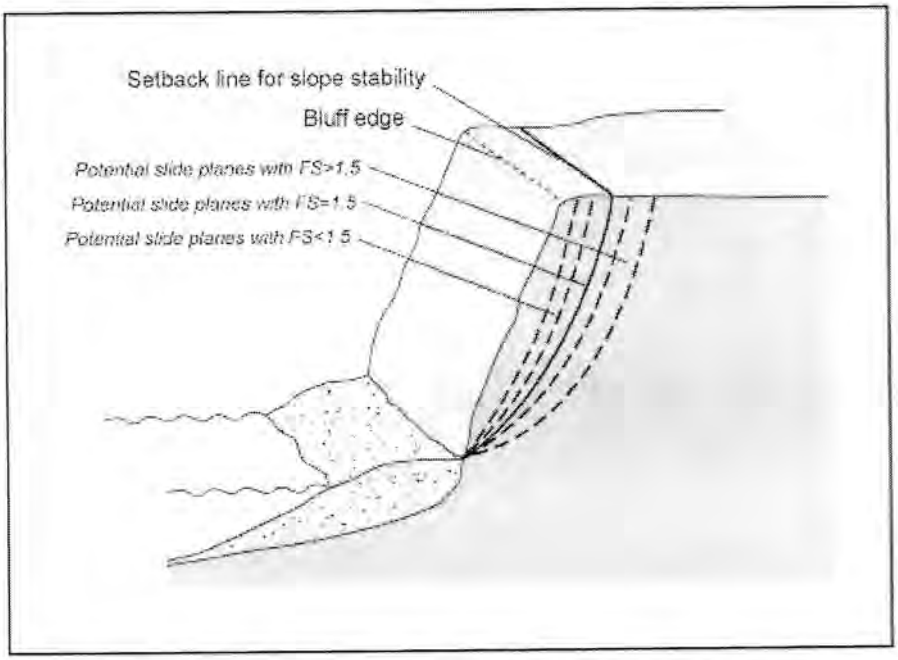

Figure 1. Establishing a development setback for slope stability. The potential slide plane possessing a defined minimum standard of stability is identified, and its intersection with the bluff edge is taken as a minimum development setback. The minimum standard for stability is usually defined as a factor of safety (FS) against sliding of 1.5 for the static case, or 1.1 for a pseudostatic (seismic) case, whichever is further landward.

Block failure of overhanging bluffs and sea caves. Assessing the factor of safety against block failure for overhanging or notched coastal bluffs, or bluffs undermined by sea caves, is far more difficult than conducting a slope stability analysis against landsliding. This is due to several factors, the most important of which are: 1) uncertainty as to the presence of local heterogeneities or planes of weakness, hidden in the bluff, that commonly control block failures, 2) difficulty in assigning shear strength values to such heterogeneities even if they can be identified, and 3) greater complexity in modeling the stress field within a bluff in terms of heterogeneities or planes of weakness as compared to a modeling a homogenous slope. The current state of the science does not allow for the calculation of a factor of safety against block failure for such overhanging or notched coastal bluffs, or bluffs undermined by sea caves, and even makes any form of quantitative assessment of the risk of failure extremely difficult. Promise is shown in mathematical models such as that of Belov and others (1999), but translating such process-oriented models into setback methodologies has not yet been attempted.

Accordingly, establishing appropriate setbacks from overhanging or undermined coastal bluffs is problematic at best. An appropriate conservative approach is to project a vertical plane upward from the rear wall of the overhang, notch, or sea cave, and establish this as the minimum setback line. This approach has been adopted by the City of San Diego, and codified in the City's Local Coastal Program. Although it is certainly possible that failure could occur along a line inclined either seaward or landward from the rear wall of the overhang, notch, or sea cave, a vertical plane would seem to be a good default configuration to assume in the absence of more compelling evidence for another configuration. Further, vertical, bluff-parallel fractures—perhaps related to stress-relief at the free face represented by the bluff face—are a common feature of otherwise homogenous coastal bluffs. In many cases, such a plane will intersect the sloping bluff face seaward of the bluff edge, and no setback from the bluff edge would be necessary to assure stability from block collapse. In cases where the plane intersects the bluff top seaward of a setback line established for landsliding, as discussed above, no additional setback would be necessary to assure stability from block collapse. In the rather rare case, however, in which the plane intersects the bluff top landward of both the bluff edge and any setback line for landsliding, the line of intersection of the plane and the bluff top would be an appropriate setback line for slope stability considerations.

Long Term Bluff Retreat

The second aspect to be considered in the establishment of a development setback line from the edge of a coastal bluff is the issue of more gradual, or "grain by grain" erosion. In order to develop appropriate setbacks for bluff top development, we need to predict the position of the bluff edge into the future. In other words, at what distance from the bluff edge will bluff top development be safe from long-term coastal erosion?

The long-term bluff retreat rate can be defined as the average value of bluff retreat as measured over a sufficient time interval that increasing the time interval has negligible effect on the average value (a statistical basis could be applied to the term "negligible," but this is rarely done). This definition implies that the long-term bluff retreat rate is linear, an assumption that certainly is not valid over time scales of more than a few centuries, or in periods of rapid sea-level change such as the late Pleistocene/early Holocene (Curray 1965; Emery and Garrison 1967; Milliman and Emery 1968). There is some overlap between slope stability issues and long-term bluff retreat issues, in that the "grains" may be fairly large rocks, and in that shallow slumping is a common mechanism for gradual bluff retreat. In addition even gradual bluff retreat tends to be highly episodic due to a host of internal and external factors.

The rate at which gradual bluff retreat occurs generally is measured by examining historic data. This is somewhat problematic in that the historic bluff retreat rate may not accurately predict the future bluff retreat rate (Watson 2002). This is a particularly issue in light of the likelihood of an acceleration in the rate of sea level rise as a result of global warming (Intergovernmental Panel on Climate Change 2001) and the resulting likely increase in bluff retreat rate (Bray and Hooke 1997; Watson 2002).

Nevertheless, historic data currently are our best indicators of future erosion at any given site. Such data may include surveys that identify the bluff edge, in which case the criteria used to identify the bluff edge must be the same in the surveys that are compared. Sufficiently detailed surveys are rare, however, and vertical aerial photography is more commonly used to assess changes in bluff position through time. The best data are those compiled photogrammetrically, whereby distortions inherent to aerial photography (due, for example, to tilting of the camera, variations in the distance from the camera to various parts of the photograph, and differences in elevation across the photograph) are corrected (see, for example, Moore 2000). Sometimes such data have been gathered as parts of specific studies of coastal bluff retreat, but more commonly they are collected as part of other work, and must be sought out for coastal erosion studies.

Coastal bluff retreat tends to be temporally episodic due to a variety of external and internal factors. External factors include tides, episodic wave events (spurred by either local or distant storms), episodic rainfall events (Kuhn 2000), El Niño-Southern Oscillation events (Griggs and Johnson 1983; Griggs 1998; Griggs and Brown 1998; Lajoie and Mathieson 1998; Storlazzi and Griggs 2000), major earthquakes (Plant and Griggs 1990; Griggs and Scholar 1997) and long-term climate change on a multidecadal to century scale (Inman and Jenkins 1999). Internal factors include the autocyclicity inherent to many bluff failure mechanisms (Leighton and Associates Inc. 1979; Hampton and Dingler 1998) and bluff response to continued toe erosion (Sunamura 1992).

Despite the episodic nature of coastal bluff retreat, it is necessary to identify the future long-term bluff retreat rate in order to establish appropriate development setbacks. The episodic nature of bluff retreat makes any calculated rate highly dependent on sampling interval. To illustrate the dependence of calculated long-term bluff retreat rates on sampling interval, it is useful to perform a sensitivity analysis from real data. Unfortunately, there are insufficient data to perform a meaningful analysis for any one site in California. Accordingly, a synthetic data set was created as part of this study.

A Synthetic Data Set. Creating and examining a synthetic data set allows for testing the effects of sampling on the determination of long-term bluff retreat rates. The long-term retreat rate is, by definition, known for the synthetic data set. Further, a synthetic data set can be created that is both longer and more complete than any such data set available from nature. The data set considered here (available upon request from the author) was created for a hypothetical 200-year period, assigned the dates 1800-2000. Figure 2 is a graphical representation of the data set, and charts the progressive retreat of the hypothetical bluff edge through that time period. Although the data are fictitious, they roughly correlate with well-known periods of episodic erosion in coastal California, at least for the second half of the data set.

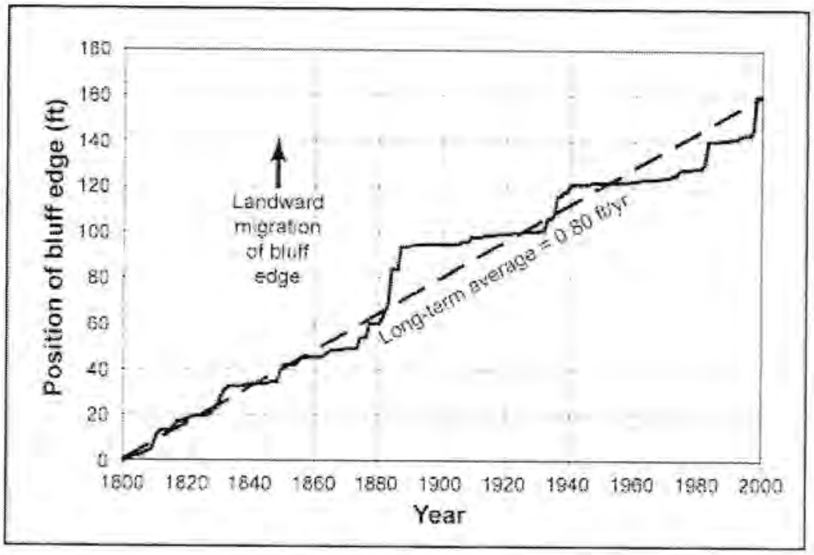

Figure 2. Plot of the position of the top edge of a hypothetical coastal bluff over time. These data represent a synthetic data set that is meant to roughly mimic typical episodic bluff retreat. Although fictitious, the data correlate well with what is know of temporal variations in erosion rate for a typical California bluff experiencing moderate erosion. The data set is far more complete than actual data available at any given site, however, making possible a sensitivity analysis of sampling interval on the calculation of the long-term bluff retreat rate.

Moving averages. A standard statistical method to smooth spikes in data is to average the data over a window of some width, while moving that window through the data set. Figure 3 shows the effect of applying this technique to the synthetic data set, using averaging windows of various widths. The first derivative of the curve representing bluff edge position through time (Figure 2) is the "instantaneous" bluff-retreat rate, and varies from 0 to 15 ft/yr for the synthetic data set (Figure 3). As the averaging window increases in width, the maximum retreat rate values decrease and the minimum values increase, effectively smoothing and broadening the "peaks" representing episodic erosion events. Depending on how the window is centered on the point representing the window average, peaks may be offset in time as well. With the widest sampling windows, peaks are essentially eliminated, and the retreat rate calculated approaches the average long-term retreat rate for the entire data set (0.80

ft/yr). Note that it is only when the window width approaches (and exceeds) 50 years in width that the calculated bluff retreat rate approaches the long-term average rate.

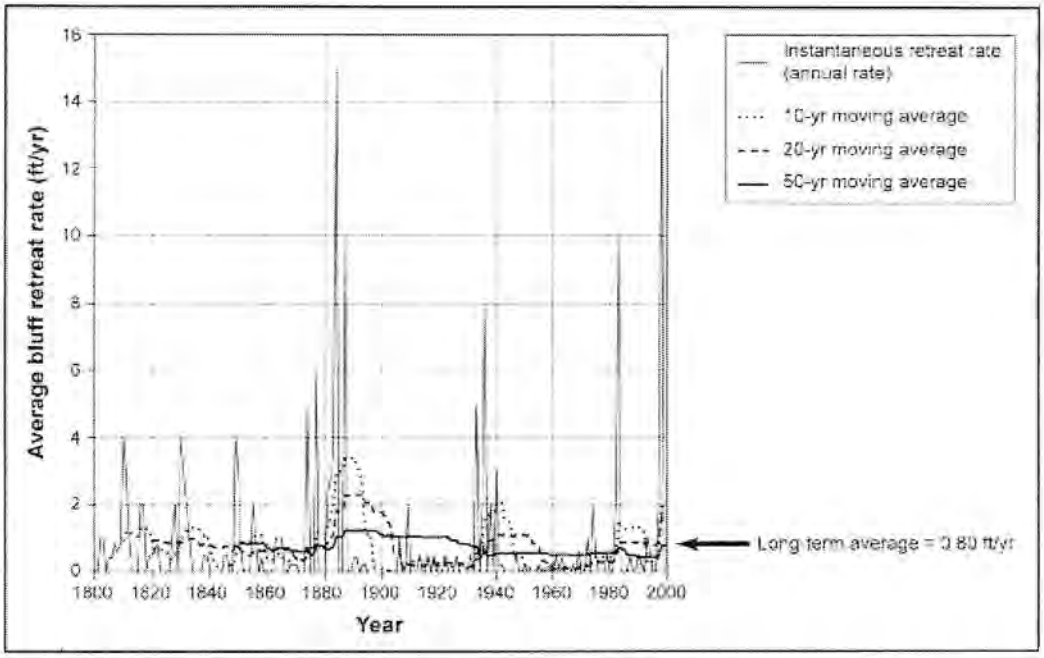

Figure 3. Average annual bluff retreat rate calculated from the synthetic data set using moving averages with various averaging window sizes. Only when data are averaged over ~50 years or more does the calculated annual bluff retreat rate approach the known long-term average for the data set.

Data gathered at intervals. Data regarding bluff edge position are almost always gathered at widely spaced intervals, corresponding to the dates of surveys or photographs. This precludes the use of a moving average technique, which depends on continuous data. Figure 4 shows the calculated bluff retreat rates at regularly spaced intervals of 10, 20, and 50 years. A wide range of values for the bluff retreat rate are obtained at the shorter sampling intervals. Although short sampling intervals give the most information on the variability of bluff retreat, the best estimate of the long-term bluff retreat rate is provided by sampling at long time intervals. Even at these long time intervals, if a statistically greater- or lesser-than-average number of "episodic events" are included in the sample, then the bluff retreat rate calculated for that interval will seriously over- or underestimate actual the long-term average bluff retreat rate.

Principal observations from the synthetic data set. A few simple generalities can be made from this limited analysis. First, instantaneous bluff retreat rates can exceed the long term average rate by a factor of many times. This is also true for data collected at short (= ~10 years for the synthetic data set) time intervals. Second, data collected at relatively short time intervals give useful information on the episodic nature of bluff retreat, but do not provide accurate estimates of long-term average bluff retreat rates. Third, the best estimate of long-term average bluff retreat rate is obtained by sampling over long (= ~50 years for the synthetic data set) time intervals. Finally, in order to accurately estimate the long-term bluff retreat rate, a stochastically appropriate number of episodic events must be included in the sampling interval. These observations, as well as similar observations from real data, lead to the general guidelines for estimating the long-term average bluff retreat rate at a site that are presented in Table 2.

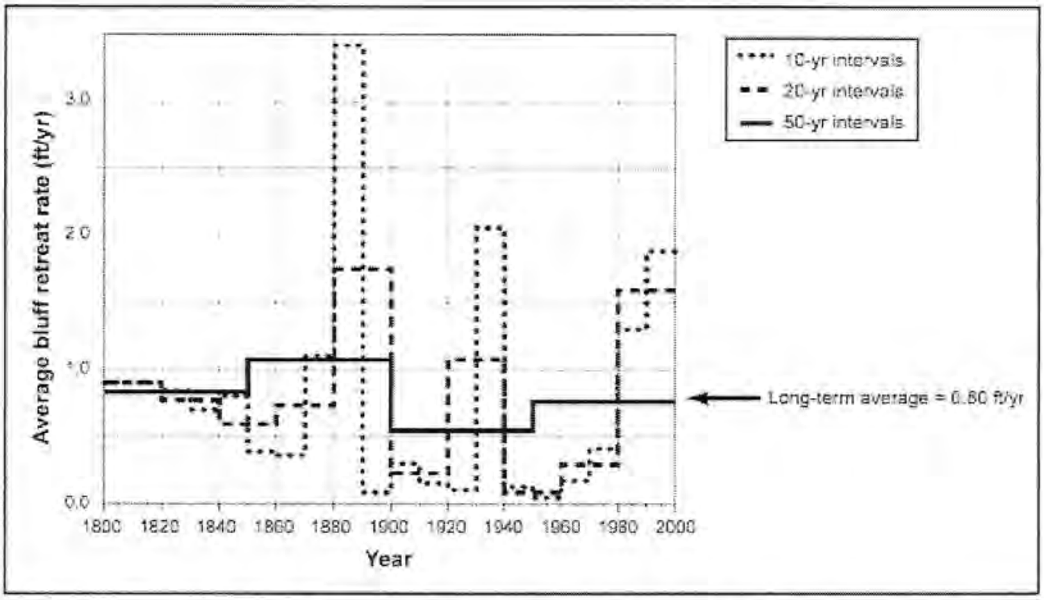

Figure 4. Average annual bluff retreat rate calculated from the synthetic data set using discrete sampling intervals of various sizes. Only when data are sampled at intervals of ~50 years or more does the calculated annual bluff retreat rate approach the known long-term average for the data set.

Establishing setbacks for long-term bluff retreat. Once an historic long-term bluff retreat rate has been estimated, establishing a setback for long-term bluff retreat rate is a simple matter of multiplying that rate, B, by the design life of the development, t. This is equivalent to predicting the position of the coastal bluff edge at the end of the design life of the structure (Figure 5).

Although this is the usual method of establishing setbacks for long-term bluff retreat in California, inherent assumptions and difficulties must be born in mind. Foremost among these is the necessity of defining the design life of the development. Because the landward retreat of an unarmored shoreline is inevitable and ongoing during a period of relative sea level rise, it is impossible to assure the safety of development from coastal erosion unless a time frame is assigned at the onset. But assigning a design life is difficult, and there is nothing in land use law that requires the abandonment of development at the end of its assigned design life.

Other problems associated with this type of analysis revolve around its inherently historic approach. There is no *a priori* reason to believe that bluff retreat rates are, or will continue to be, linear. This is especially relevant in light of expected acceleration of the historic rate of sea level rise as a result of global warming (Intergovernmental Panel on Climate Change 2001). Further, there is good evidence that erosion rates can be highly variable through time (Jones and Rogers 2002). For all of these reasons it is important to adopt a conservative approach to estimating long-term bluff retreat rates.

Table 2. Guidelines for establishing long-term bluff retreat rates

1) Determine bluff edge positions at as many times as possible, but covering a minimum of about 50 years and extending to the present. Common data sets include vertical aerial photographs, surveys that identify the bluff edge, and detailed topographic maps. These sources must be of sufficient scale or precision to locate accurately the position of the bluff edge to within a few feet.

2) If aerial photographs are used, the best results are obtained through photogrammetric methods, whereby distortions inherent to aerial photography are corrected (orthorectified). Even if photogrammetric methods are not used, the scale of the photographs must be carefully determined by comparison of the image size of known features to their actual size.

3) When comparing bluff edge positions on aerial photographs or unanchored surveys, a "shoreline reference feature" must be identified that has been static through time and is identifiable in each data set. Bluff positions throughout the area of reference can be measured relative to this feature. Common shoreline reference features are road centerlines, structures, large rock outcrops, or trees.

4) When comparing bluff edge positions on surveys, it is critical that the same criteria for the identification of the bluff edge was used in each survey. The Coastal Act definition of a bluff edge can be found in California Code of Regulations, Title 14, § 13577 (h) (2).

5) Although the short-term erosion rate for each time interval between data points provides valuable information regarding the nature of bluff retreat at the site, the long-term erosion rate should be determined from the extreme end-points of the time series examined. This time series should exceed 50 years in length, and should include both relatively quiet periods, such as the 1950's-1960's; and the more erosive subsequent time periods (especially the 1982-1983 and 1997-1998 El Niño winters).

6) In larger study areas, the bluff retreat rate should be determined at intervals along the bluff edge, paying special attention to potential differences in retreat rate between headlands and coves, and amongst areas underlain by differing geologic materials.

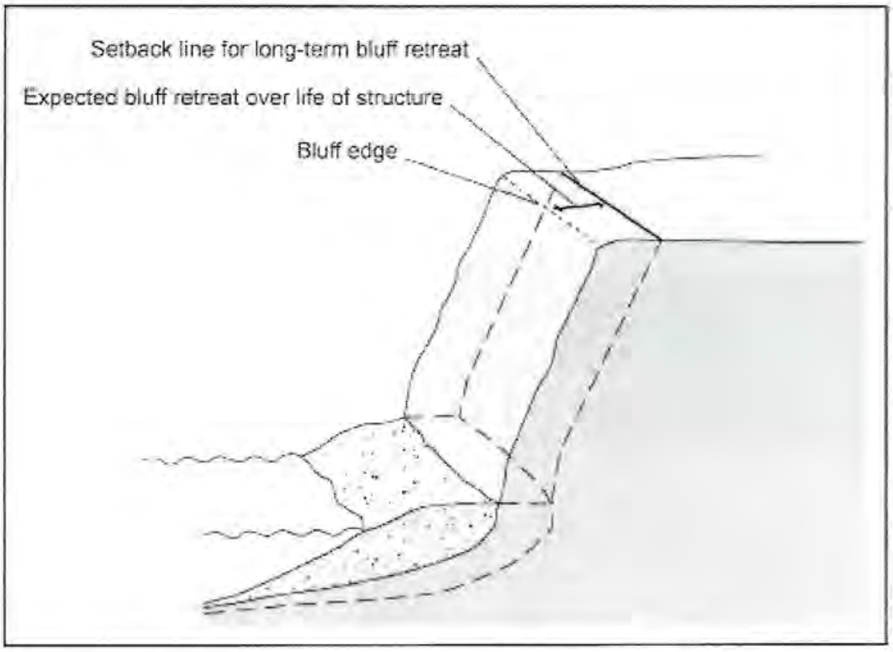

Figure 5. Establishing a development setback for long term bluff retreat. The expected bluff position at the end of the development's useful life is found by multiplying the average annual bluff retreat rate by the design life of the development; this line is taken to represent the minimum setback for long-term bluff retreat.

Uncertainty

There is a great deal of uncertainty in many parts of the analysis discussed above. The deterministic approach outlined here does not deal well with such uncertainty. Various methods have been used to build in some margin for error in establishing safe building setbacks. One approach, commonly used by geologists working in northern California, is to multiply the long-term bluff retreat rate by a factor of safety (used in a different sense than for slope stability), generally ranging from 1.5 to 4.0. More commonly, a simple "buffer" is added to the setback generated by multiplying the long-term bluff retreat rate by the design life of the structure. This buffer, generally on the order of ten feet, serves several functions: 1) it allows for uncertainty in all aspects of the analysis; 2) it allows for any future increase in bluff retreat rate due, for example, to an increase in the rate of sea level rise (Bray and Hooke 1997; Watson 2002); 3) it assures that at the end of the design life of the structure the foundations are not actually being undermined (if that were to be the case the structure would actually be imperiled well before the end of its design life); and 4) it allows access so that remedial measures, such as relocation of the structure, can be taken as erosion approaches the foundations. If a slope stability setback is required (*i.e.*, if the bluff does not meet minimum slope stability standards), that setback can do double duty as this buffer.

Summary: Defining the Total Setbacks for Bluff-Top Development

To define the total development setback, one must combine the two aspects of the setback considered above: the setback to assure safety from landsliding or block failure, and the setback for long-term bluff retreat. The resulting setback assures that minimal slope stability standards are maintained for the design life of the structure.

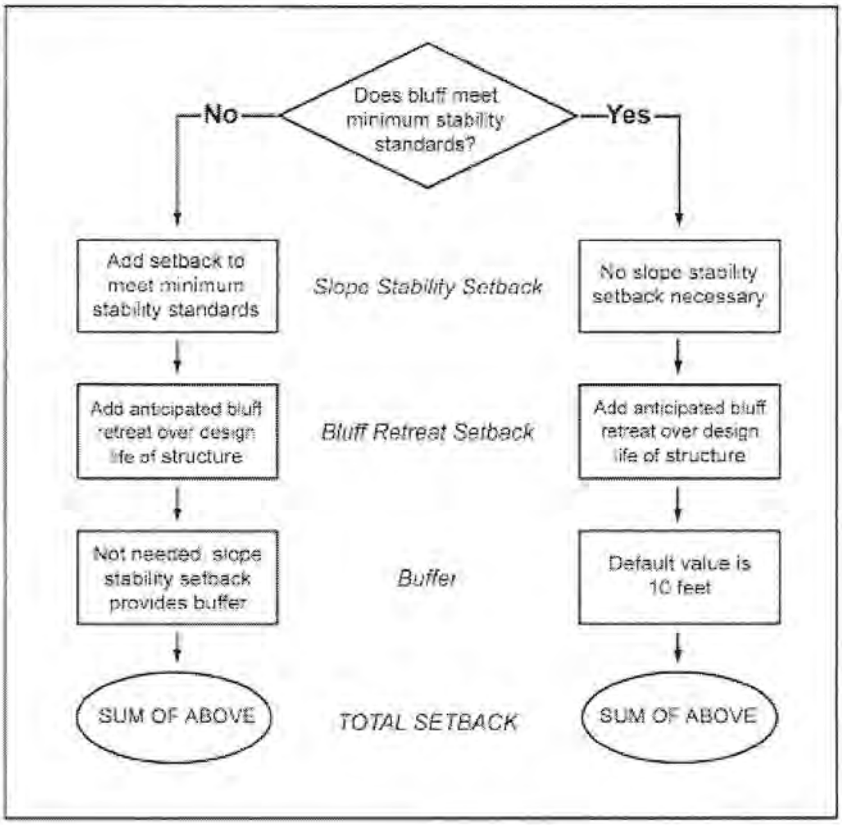

Figure 6. Flowchart for establishing bluff edge setback for development, taking into account stability of the bluff, long-term bluff retreat, and uncertainty in the analysis.

A methodology for combining these setbacks is outlined in Figure 6. First, it must be determined whether the coastal bluff meets minimum slope stability standards. Normally, this will be a factor of safety of 1.5 (static) or 1.1 (pseudostatic). If the answer to this question is "yes," then no setback is necessary to assure slope stability. If the answer is "no," then it is necessary to determine the position on the bluff top where the minimum slope stability standards are attained. This position, as measured relative to the bluff edge, is the setback necessary for slope stability determined as described above. In the case of block failure of an overhanging bluff or collapse of a sea cave, the setback necessary to assure stability from this type of collapse is equivalent to the slope stability setback. Although the current state of the science makes it impossible to quantitatively assess stability relative to this type of failure, a conservative, yet realistic, setback line is the projection of a vertical plane from the rear wall of the overhang or sea cave on the bluff top. If the plane does not intersect the bluff top (*i.e.*, intersects the inclined bluff face seaward of the bluff edge), then no setback for this type of collapse is necessary.

The next step is to determine the expected bluff retreat over the design life of the structure, as described above. This setback is added to the slope stability setback, if any.

Finally, a buffer, generally a minimum of 10 feet, should be added to address uncertainty in the analysis, to allow for any future increase in the long-term bluff retreat rate, to assures that the foundation elements aren't actually undermined at the end of the design life of the development, and to allow access for remedial measures. A buffer is not necessary if the slope stability setback equals or exceeds about ten feet, as it can do "double duty" as both a setback to assure slope stability and a buffer for the purposes listed above.

The total setback is meant to assure that minimum slope stability standards are maintained for the design life of the development. Inherent in this analysis is the assumption that factors affecting slope stability (steepness and shape of the slope, ground water conditions, geometry of rock types exposed in the bluff) will remain constant through the design life of the development, that the future bluff-retreat rate will be linear and of comparable magnitude to the historic rate, and that the nature of erosion processes at the site will remain unchanged. All of these assumptions are potentially flawed, but in the absence of convincing evidence to the contrary, are a means of establishing reasonable development setbacks.

Towards Probabilistic Coastal Erosion Hazard Assessment

The deterministic approach presented above is based on established geologic and engineering principals, and similar approaches have been used to establish development setbacks from slope edges throughout the world for some time. However, the approach suffers from its limited ability to consider uncertainties in the analysis. Probabilistic approaches, on the other hand, inherently consider analytical uncertainties, and allow for a better definition of risk. This type of risk assessment has been routine for decades in the field of hydrology, where design basis and land use priorities are based on the magnitude of the "100-year flood," for example. Probabilistic coastal hazard assessment similarly can be used to quantify the likelihood that the bluff edge will erode to any particular point on a bluff top in a given time. Then, by establishing an acceptable level of risk (for example, a probability of <5% that the bluff edge will reach a certain point over the design life of the development) a setback line can be established that inherently includes uncertainties in the analysis. Just as the seismological community has moved away from deterministic methods towards probabilistic ones, such an approach allows for better consideration of the uncertainties in estimating future coastal erosion.

Probabilistic coastal hazard assessment is in its infancy, and no standardized methods have won acceptance—or even much discussion. The failure of coastal bluffs along Lake Michigan through landsliding has been assessed probabilistically by Chapman and others (2002), through the use of probabilistic slope stability analyses. Lee and others (2001) applied a variety of probabilistic methods to questions of coastal bluff retreat in England. Methods that they evaluated include the simulation of recession of episodically eroding cliffs through Monte Carlo techniques, the use of historical records and statistical experiments to model the behavior of cliffs affected by episodic landslide events, event-tree approaches, and the evaluation of the likelihood of the reactivation of ancient landslides. All of these techniques show promise, but the authors restricted themselves to specific cases. What is needed is the development of probabilistic methods that will work in more general cases, and combine both slope stability and long-term bluff retreat considerations. One way to approach this problem is to consider separately the two aspects of defining a development setback as outlined above.

Probabilistic slope stability analyses already are routine (Mostyn and Li 1993; Yang et al. 1993). In addition to quantifying the probability of slope failure (something not done in a deterministic slope stability analysis, which only establishes whether or not failure will occur), probabilistic slope stability analysis allows for consideration of variability or uncertainty in soil or rock strength parameters (Lumb 1970). Uncertainties in these input parameters are quantified by the standard deviation of each parameter. Then, using Monte Carlo techniques, a probability distribution for the factor of safety associated with any given failure plane is produced. From this, the probability of failure along the chosen potential failure plane can be calculated. The probability of failure is the probability that the factor of safety will be less than 1.0, and can be calculated for any given potential failure surface. By performing such analyses on a variety of potential failure surfaces intersecting different portions of the bluff top, a probability could be assigned to any position on the bluff top quantifying the likelihood that a failure will occur landward of that point.

Although not routine, several possibilities present themselves for developing probabilistic models for gradual, episodic, bluff retreat. Perhaps the simplest method of quantifying uncertainty is the application of a confidence interval to the estimate of the long-term average bluff retreat rate. Each time interval examined in estimating this rate is one sample of the mean value. For normally distributed data (or data that can be transformed to a normal distribution by, for example, a log transform), the sample standard deviation is a traditional estimate of uncertainty. There is a ~68.26% probability that the true mean value will lie within ±1 standard deviation of the sample mean. Different probabilities apply to different multiples of the standard deviation. Thus, uncertainties in the product ($B \times t$), above, can be quantified and contoured on the bluff top. For populations that cannot be shown to be normally distributed (likely the case with the small sample sizes available for bluff retreat rates), a better estimate of uncertainty may be a confidence interval based on Student's t distribution, or on nonparametric statistics.

A second approach to probabilistic assessment of coastal bluff recession is to treat annual bluff retreat in a manner analogous to river floods. Thus, the recurrence interval of a particular amount of annual bluff retreat can be calculated by the formula

$$R = \frac{N+1}{M}$$

where R is the recurrence interval, N is the number of years of record, and M is the rank of the annual bluff retreat in the total data set. For the synthetic data set considered above, there are many duplicate values due to the limited precision with which bluff retreat data are generally reported. Eliminating duplicates, and ranking the annual bluff retreat rates, recurrence intervals can be calculated. These data can be graphed in order to arrive at the expected amount of bluff retreat for any particular recurrence interval (Figure 7). The inverse of the recurrence interval is the annual probability that a given amount of bluff retreat will be exceeded. Such data may be especially valuable in assessing the risk of occurrence of an episodic event sufficient to threaten an existing structure.

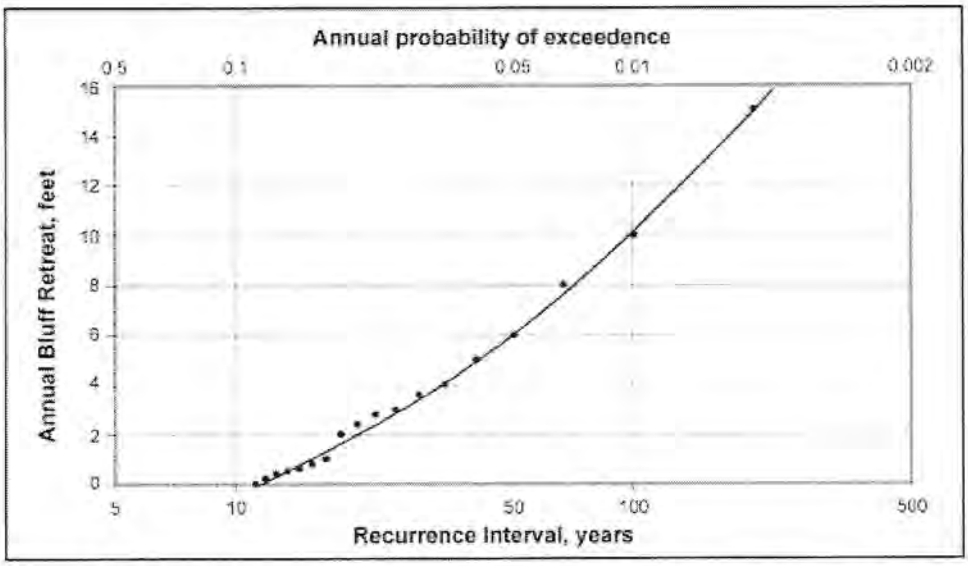

Figure 7. Recurrence interval for annual bluff retreat, calculated for the synthetic data set. The recurrence interval, calculated in a manner analogous to flood recurrence interval, gives the average time between years with a given amount of bluff retreat. The inverse of the recurrence interval is the statistical probability that a given amount of bluff retreat will occur (or be exceeded) in any given year.

The total risk to bluff-top development, which includes both long-term bluff retreat and slope failure, can be calculated by multiplying the probability of slope failure at a given position by the probability that bluff retreat will reach that point by a given time. The geotechnical and planning communities will need to establish what is an acceptable probability, or risk, that the bluff will reach a given point in order to develop setback criteria. Once that probability is established, the setback line can be defined as the locus of points on the bluff top at that probability.

A prime difficulty in applying probabilistic methods to assessing coastal erosion risk will be the difficulty in acquiring sufficiently rich data sets with which to work. More effort is needed at acquiring long, precise data sets on coastal erosion in a variety of geologic conditions throughout the state.

Acknowledgements

This paper grew out of the need to clarify and make public the analytic methods of Coastal Commission staff in evaluating proposals for bluff-top development. As such, the ideas presented here grew out of numerous discussions with various members of the Commission staff, especially Lesley Ewing and others on the Shoreline Erosion Task Force, and with members of the geotechnical and coastal geology community at large. The State of California provided support to develop this paper, and the manuscript benefited from critical reviews by Ralph Faust, Sandy Goldberg, and Amy Roach.

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Appendix C
Addendum to Program EIR

ADDENDUM TO PROGRAM ENVIRONMENTAL IMPACT REPORT for the 2011 *Plan Santa Barbara* General Plan Update (SCH 2009011031)

FOR: CITY OF SANTA BARBARA 2013 SAFETY ELEMENT

April 30, 2013

This addendum to the certified Final Environmental Impact Report (FEIR) for the 2011 *Plan Santa Barbara* General Plan Update documents California Environmental Quality Act (CEQA) analysis for the 2013 Safety Element. The Element would amend the City of Santa Barbara General Plan and replace the existing 2011 General Plan Safety and Public Services Element (including 1979 Safety Element policies and 2011 Update policies) and the 1981 Local Coastal Program (LCP) Hazards Section. Several existing policies will be moved to the Environmental Resources Element. Others policies have been repositioned in the 2013 Element or deleted when no longer necessary. The intent of the Element is to avoid or reduce the risks and effects of natural and human-caused hazards in Santa Barbara. The 2013 Safety Element policies would incorporate and augment General Plan policies and programs previously studied in the citywide General Plan Program FEIR, and do not raise new environmental issues or significant impacts.

EIR ADDENDUM PROCEDURES

This EIR Addendum is prepared in accordance with State CEQA Guidelines Sections 15168 (Program EIR) and 15164 (Addendum to an EIR).

Section 15168 provides that a Program EIR may be prepared on a series of actions characterized as one large project, such as a citywide General Plan update. This allows for a comprehensive consideration of policies and effects, and avoids later duplicative environmental analysis. When subsequent implementing actions are undertaken, the activities may be approved as within the scope of the Plan covered by the Program EIR when no new significant effects would occur.

Section 15164 provides that an Addendum to a previous EIR may be prepared to document changes that make the prior EIR adequate for the current project when the changes do not involve new significant impacts or substantial increases in previously identified impacts.

The Guidelines provide that an EIR Addendum need not be circulated for public review, but is attached to the EIR. The decision-making body (City Council) considers the Addendum together with the certified EIR in making a decision on the project.

PRIOR ENVIRONMENTAL DOCUMENT

The Program Environmental Impact Report (EIR) for the 2011 General Plan update was certified by the Planning Commission in September 2010 and by City Council in December 2011.

The General Plan Program EIR evaluated citywide effects on the environment from incremental growth to the year 2030 under General Plan policies and programs. The General Plan contemplates growth by the year 2030 of up to 1.5 million square feet of net additional commercial and other non-residential development and up to 2,800 additional housing units. **Class 1 Impacts**

The EIR analysis identified significant traffic and climate change impacts that could not be fully mitigated (Class 1 impacts) from General Plan policies and citywide incremental growth to the year 2030. An increase from 13 to 20-26 roadway intersections at 77% or greater volume-to-capacity ratio was identified. Citywide greenhouse gas emissions were projected as increasing and therefore potentially not meeting State AB 32 emission reduction targets for 2020 and then-undefined SB 375 regional targets.

The EIR also identified that these traffic and climate change impacts could potentially be substantially reduced with implementation of a robust expansion of transportation demand management measures including parking pricing. These mitigation measures were included in the General Plan but City Council found that providing an upfront commitment as to the extent and method and timing of implementation was not feasible. As such, full mitigation credit was not given for the purpose of CEQA impact analysis. In adopting the General Plan, the City Council adopted findings of overriding consideration that the benefits of the Plan outweighed these potential significant impacts, thereby finding these impacts to be acceptable.

An Addendum to the FEIR (6-18-12) for the proposed City Climate Action Plan documented further analysis of climate change demonstrating that impacts associated with citywide greenhouse gas emissions would be less than significant (Class 2).

Class 2 Impacts

The EIR analysis identified the following potentially significant impacts that could be mitigated to less than significant levels (Class 2 impacts): air quality (*diesel emissions*); biological resources (*upland and creek/riparian habitats and species*); geological conditions (*sea cliff retreat*); heritage resources (*effects of development on historic resources*); hydrology (*extended range sea level rise*); noise (*transportation noise*); open space (*loss or fragmentation of open space*); public utilities (*solid waste management*); and transportation (*intersections with roadway improvement mitigation; roadway corridor congestion*).

Identified mitigation measures associated with these impacts were incorporated into the General Plan as policies and programs.

Class 3 Impacts

The EIR analysis concluded that with policies and programs already in place, the following other impacts would be less than significant (Class 3 impacts): air quality (*consistency with Clean Air Plan for air quality standards; construction emissions*); biological resources (*grasslands; coastal resources; individual specimen trees*); geological conditions (*seismic, geologic, soil hazards*); hazards (*accident risks, wildfire; hazardous materials*); heritage resources (*archeological and paleontological resources*); hydrology and water quality (*development in floodplains and near creeks; storm water runoff; water quality of creeks, groundwater, coastal and marine water*); noise (*noise guidelines; mixed use nuisance noise; construction noise*); open space and visual resources (*scenic views; community character; lighting*); public services (*police; fire protection; parks and recreation; schools*); public utilities (*water supply, wastewater treatment*); transportation (*reduction in per capita vehicle commute trips – Class 4 beneficial*).

Additional Environmental Analysis

The EIR also included detailed analysis of impacts associated with energy, climate change (both greenhouse gas emissions contributing to climate change, and climate change effects on the City), population and jobs/housing balance, and socioeconomic issues.

CHANGES IN ENVIRONMENTAL CIRCUMSTANCES

No substantial changes in environmental circumstances on the ground have occurred since the December 2011 General Plan adoption and EIR certification. No changes to relevant Federal or State regulations or guidelines have occurred.

CURRENT PROJECT DESCRIPTION: PROPOSED SAFETY ELEMENT UPDATE

The 2013 Safety Element includes updated information describing natural- and human-caused hazards that may affect the City; provides maps depicting areas of the City that may be affected by hazards; describes actions being implemented by the City to reduce hazard-related risk, and to respond to emergencies that do occur.

The proposed goals, policies, and implementation measures in the 2013 Safety Element are similar to the policies within the existing 1979 Safety Element and 1981 Local Coastal Plan, and the new policies analyzed in the 2011 General Plan Update Safety and Public Services Element. They include policies pertaining to:

- Emergency Response Planning
- Geologic and Seismic Hazards
- Fire Hazards
- Flooding Hazards
- Hazardous Materials
- Public Safety
- Public Services

Policies provided by the 2013 Safety Element address the hazards identified by the Element and are intended to promote community resilience, minimize risk presented by natural- and human-caused hazards, and facilitate the City's development review process. All of the topics covered by the existing Safety and Public Services Element are covered in the 2013 Safety Element. Existing policies related to water supply, wastewater, and solid waste management will be transferred to the Environmental Resources Element of the General Plan.

The hazard reduction and response planning policy issue areas addressed in the 2013 Safety Element are summarized below:

Emergency Response Planning. These policies address issues related to promoting community resilience; and the ability of the community to respond to emergencies, disasters and possible climate change-related effects.

Development Review. Policies provided in this section promote hazard-related risk reduction through the avoidance of areas subject to hazards, the implementation of project-specific design measures, compliance with applicable regulatory requirements, and the implementation of mitigation measures identified during the development review process.

Geologic and Seismic Hazards. These policies address the various hazards that have the potential to affect Santa Barbara, and provide development review requirements and project design measures that minimize hazard-related risk. Hazards addressed include earthquake fault rupture, ground shaking, liquefaction, tsunami, seiche, landslides, sea cliff retreat, soil erosion, expansive soils, radon, and high groundwater.

Fire Hazards. This section provides policies that promote wildfire hazard risk reduction through actions such as development limitation, vegetation management, defensible space requirements, creek management, water supply, and evacuation routes and tactical areas in the Extreme Foothill and Foothill High Fire Hazard Zones. Policies that address post fire recovery and urban structural fires are also provided.

Flood Hazards. Policies are provided to reduce impacts that may result from stream flooding and inundation due to dam failure. Policies also address the implementation of appropriate actions to minimize coastal erosion and inundation effects that could be caused by a climate change induced rise in sea level.

Hazardous Materials. Policies are provided to reduce the potential for exposure to hazardous materials from prior land or groundwater contamination and pest control, and provide for proper disposal of household hazardous waste and pharmaceutical waste.

Public Safety. This section provides policies to minimize risk associated with electromagnetic fields, natural gas pipelines, aircraft, and hazardous substance transportation.

Public Services. These policies address safety-related infrastructure improvements, and include items such as providing funding for improvements to structures and services that should remain functional during a disaster or emergency.

PROJECT IMPACTS AND MITIGATIONS

Geologic, Hazards, and Hydrology Impacts

Based on careful analysis of existing environmental conditions, extensive existing City policies and programs, and General Plan update polices addressing growth and the environment, the General Plan FEIR concluded that many safety-related impacts would be less than significant (Class 3), including those pertaining to geological conditions (seismic, geologic and soil hazards), hazards (accident risks, electromagnetic files, hazardous materials exposure, wildfire hazards), and hydrology (flooding). The 2013 Safety Element retains and augments the protective policies addressing these issues, and no change to identified less than significant impacts would result.

The analysis of geological conditions in the FEIR identifies a potentially significant impact from the effect of continuing sea cliff retreat on a small number of structures that could be developed or modified near coastal bluffs over the next 20 years under the General Plan. The 2013 Safety Element carries forward the EIR coastal bluff retreat mitigation measures for shoreline management planning and development guidelines that were included as policies in the 2011 General Plan and Climate Action Plan. The policies have been revised slightly to enhance clarity regarding threatened coastal properties and the use of coastal protection structures, and augmented with additional land use and design guidance (2013 Safety Element policies S18.0, S19.0, S20.0, S20.1, S20.2, S20.3, S21). With inclusion of these identified mitigating policies, potential significant impacts from sea cliff retreat will be reduced and the residual impact remains less than significant with mitigation.

The FEIR analysis of hazardous materials issues identifies a potentially significant impact from inadequate community hazardous waste collection facility capacity for the next 20 years. The household hazardous materials mitigation measure included in the 2011 General Plan policies has been retained in the 2013 Safety Element as policy S37.1. The FEIR concluded that the inclusion of this measure in the General Plan will result in avoidance of a significant impact. The residual impact remains at a less than significant level for the 2013 Safety Element.

The FEIR analysis of hydrology issues identifies a potentially significant extended range impact of increased storm flooding and inundation due to climate change - induced sea level rise along streams and drainages in lower-lying areas of the Waterfront, Downtown, and East Side. The FEIR mitigation measures for adaptive management planning were incorporated into the General Plan Environmental Resources Element and the Climate Action Plan, and are included in the 2013 Safety Element as policy S35.3 (Sea Level Rise Adaptation). Additional sea level rise adaptation measures identified in the Climate Action Plan are also reflected in the 2013 Safety Element policies S35.1 (Monitoring, Data Collection, and Analysis of Sea Level Rise), S35.2 (Sea Level Rise Risk Assessment and Vulnerability Analysis), and S36.0 (Future Inundation). The residual impact remains Class 2, less than significant with mitigation.

The existing General Plan also contains policies reflecting recommended measures identified in the FEIR that further benefit reduced impacts. The General Plan policies related to prudent avoidance of electromagnetic hazard risks (PS 9.2, PS 9.3) have been retained as S40 and S40.1 in the 2013 Safety Element. General Plan policies PS14 and PS15 regarding water system improvements for firefighting have been retained as policies S29.0 and S30.0 respectively in the 2013 Safety Element. FEIR recommended measures pertaining to pharmaceutical waste collection and integrated pest management that were included in the 2011 General Plan Environmental Resources Element have been retained.

Policies PS4, PS5, PS6 and PS7.4 of the General Plan regarding water supply will be moved into the Environmental Resources Element. Policy 9.4 related to conducting a Vapor Barrier Study has not been included in the 2013 Safety Element. This study has been completed by the Public Works Department and is available as a resource for use in the development review process. With the study complete, policy PS9.4 is no longer necessary in the Safety Element.

Additional policies included in the 2013 Safety Element replace other existing 1979, 1981, or 2011 General Plan and Local Coastal Plan policies (addressing emergency response planning, geologic and seismic hazards, fire hazard, flood hazard, hazardous materials, and public safety). These policies serve to reduce risks and hazard impacts and do not result in significant environmental impacts. No change to FEIR impact evaluation would result.

Other Environmental Impacts

The public safety policy protection measures of the 2013 Safety Element are not substantially different than those of the existing General Plan. The policies would not result in significant impacts associated with other environmental conditions (air quality, biological resources, heritage resources, water quality, noise, open space and visual resources, public services, public utilities, and transportation).

No changes from impact significance classifications identified in the FEIR (i.e., Class 1, 2, or 3 impacts) would result from the updated information and policies of the 2013 Safety Element and LCP Hazards Section Amendment.

CEQA FINDING

Based on the Addendum review of the 2013 Safety Element, in accordance with State CEQA Guidelines Section 15612, no Subsequent Negative Declaration or Environmental Impact Report is required for the project because the project setting, description, impacts, and mitigations do not involve new significant impacts or a substantial increase in the severity of impacts previously identified in the final General Plan Program EIR.

This Addendum, together with the certified General Plan Program EIR, constitutes adequate environmental documentation in compliance with CEQA for the 2013 Safety Element and LCP Hazards Section Amendment.

Prepared by: Elizabeth Limón Date: 4.30.13
Elizabeth Limón, Project Planner

Reviewed by: Barbara R. Shelton Date: 4/30/13
Barbara Shelton, Environmental Analyst

<u>References</u>:

Certified Final EIR for *Plan Santa Barbara* General Plan Update (September 2010) and FEIR Addendum (December 2011).

Addendum to Program Environmental Impact Report for the *Plan Santa Barbara* General Plan Update for Draft City of Santa Barbara Climate Action Plan (June 18, 2012).